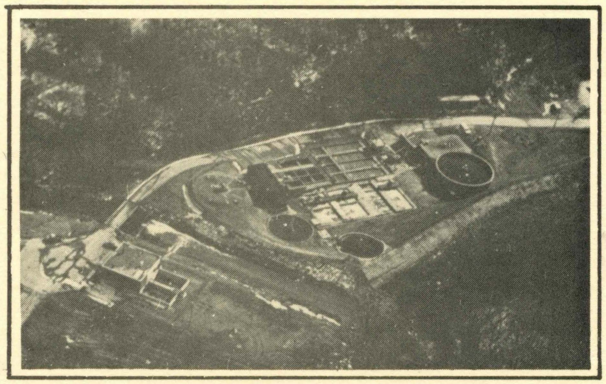
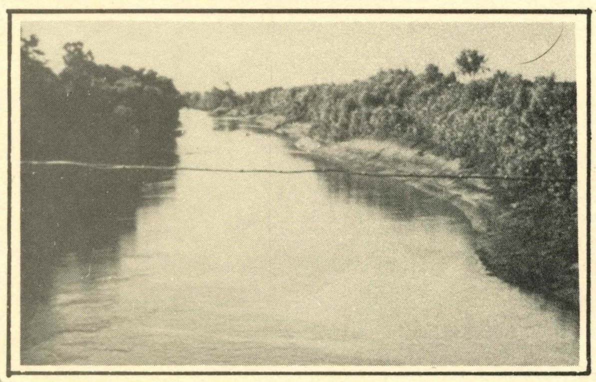
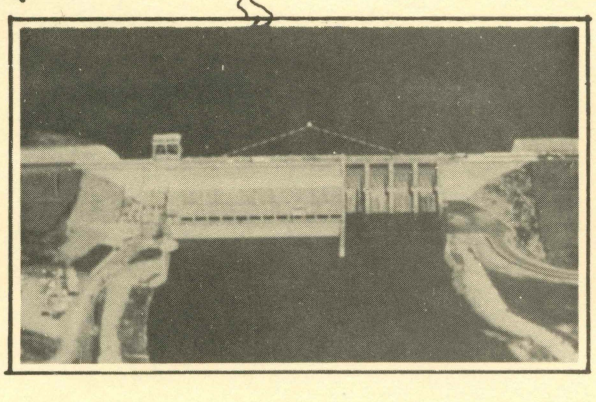
Water Quality of the Osage River Basin 1975-76



by
Richard M. Duchrow





Missouri Department of Conservation

FINAL REPORT

State of Missouri Project S-1-R-29

Study W-7

WATER QUALITY SURVEY OF THE OSAGE RIVER SYSTEM, 1975-76

Missouri Department of Conservation

Larry R. Gale, Director

Charles A. Purkett, Jr., Assistant Director

James P. Fry, Chief, Division of Fisheries

Dan F. Dickneite, D-J Coordinator

Date prepared:
January 31, 1984

Prepared by: Richard M. Duchrow
Water Quality Research Biologist

Approved by: James R. Whitley
Fisheries Research Superintendent

TABLE OF CONTENTS

Page

ABSTRACT x

INTRODUCTION 1

STUDY AREA 2

Geography and Physiography 2
Osage River and Major Tributary Descriptions 6
Osage River 6
Marais des Cygnes River 8
Marmaton - Little Osage River 9
South Grand River 10
Sac River 12
Pomme de Terre River 13
Niangua River 14

MATERIALS AND METHODS 15

Field and Laboratory Procedures 15
Data Analysis 22

RESULTS 24

Osage River Basin 24
Osage River (Mainstem) 25
Minor Mainstem Tributaries of the Osage River 41
Maries River 41
Tavern Creek 53
Gravois Creek 57
Dry and Wet Auglaize creeks 59
Deer Creek 67
Turkey Creek 71
Big Buffalo Creek 72
Cole Camp Creek 75
Clear Creek 76
Weaubleau Creek 81
Monegaw Creek 82
Marais des Cygnes River 86
Marais des Cygnes River (Mainstem) 87
Miami Creek 93
Mulberry Creek 96
Marmaton - Little Osage River 99
Marmaton River (Mainstem) 100
Dry Wood Creek 106
Little Dry Wood Creek 108
Little Osage River 110

TABLE OF CONTENTS (cont.)

	Page
South Grand River	114
South Grand River (Mainstem) and East Branch of South Grand River	116
Big Creek	127
Deepwater Creek	131
Bear Creek	134
Tebo Creek	136
Sac River	147
Sac River (Mainstem)	149
Little Sac River	161
Clear Creek	171
Bear Creek	173
Brush Creek	177
Turnback Creek	179
Limestone Creek	182
Sons Creek	185
Cedar Creek	187
Horse Creek	192
Pomme de Terre River	197
Pomme de Terre River (Mainstem)	199
Lindley Creek	208
Niangua River	212
Niangua River (Mainstem) and Bennett Spring	214
Little Niangua River	224
CONCLUSION	229
LITERATURE CITED	232
TABLES	243
APPENDIX A	309

LIST OF TABLES

Table		Page
1.	Discharges and potential pollution sources entering the Osage River system, 1975-1976	243
2.	Invertebrate sampling site locations on the Osage River and its tributaries	277
3.	Water quality criteria for unpolluted Missouri streams	22
4.	Taxonomic list of fishes collected from the Osage River and its tributaries (Pflieger 1975)	286
5.	Taxonomic list of benthic macroinvertebrates identified in samples collected from the Osage River and its tributaries, 1975-1976	296
6.	Benthic invertebrate community characteristics and coefficient of similarity values for samples collected from Maries River during 1978 and comparative data collected during the 1975-76 survey	46

APPENDIX A

Table		Page
A-1	Chemical parameters analyzed at selected invertebrate sampling sites on the mainstem Osage River, 1973-1975	309
A-2	Chemical parameters analyzed at selected invertebrate sampling sites on minor mainstem tributaries to the Osage River, 1973	311
A-3	Chemical parameters analyzed at selected invertebrate sampling sites on the Marais des Cygnes River and Miami Creek, 1973-1975	312
A-4	Chemical parameters analyzed at selected invertebrate sampling sites on the Marmaton and Little Osage rivers, 1973-1975	314
A-5	Chemical paramters analyzed at selected invertebrate sampling sites on the South Grand River and its tributaries, 1973-1975	320
A-6	Chemical parameters analyzed at selected invertebrate sampling sites on the Sac and Pomme de Terre rivers, 1973	327
A-7	Benthic invertebrate community characteristics for samples collected from the mainstem Osage River, 1975-1976	328
A-8	Coefficient of similarity matrix for invertebrate sampling sites on the mainstem Osage River, 1975-1976	329
A-9	Benthic invertebrate community characteristics for samples collected from minor mainstem tributaries of the Osage River, 1975-1976	330
A-10	Coefficient of similarity matrix for invertebrate sampling sites on minor mainstem tributaries of the Osage River, 1975-1976	332
A-11	Benthic invertebrate community characteristics for samples collected from the Marais des Cygnes River Basin, 1975-1976	333

APPENDIX A (cont.)

Table		Page
A-12	Coefficient of similarity matrix for invertebrate sampling sites on the Marais des Cygnes River Basin, 1975-1976	334
A-13	Benthic invertebrate community characteristics for samples collected from the Little Osage and Marmaton rivers, 1975-1976	335
A-14	Coefficient of similarity matrix for invertebrate sampling sites on the Little Osage and Marmaton rivers, 1975-1976	336
A-15	Benthic invertebrate community characteristics for samples collected from the South Grand River and its tributaries, 1975-1976	337
A-16	Coefficient of similarity matrix for invertebrate sampling sites on the South Grand River and its tributaries, 1975-1976	339
A-17	Benthic invertebrate community characteristics for samples collected from the Sac River and its tributaries, 1975-1976	340
A-18	Coefficient of similarity matrix for invertebrate sampling sites on the Sac River and its tributaries, 1975-1976	342
A-19	Benthic invertebrate community characteristics for samples collected from the Pomme de Terre River and Lindley Creek, 1975-1976	343
A-20	Coefficient of similarity matrix for invertebrate sampling sites on the Pomme de Terre River and Lindley Creek, 1975-1976	344
A-21	Benthic invertebrate community characteristics for samples collected from the Niangua, Bennett Spring, and Little Niangua rivers, 1975-1976	345
A-22	Coefficient of similarity matrix for invertebrate sampling sites on the Niangua, Bennett Spring, and Little Niangua rivers, 1975-1976	346
A-23	Summary of similar benthic macroinvertebrate communities in the Osage River Basin listed by sample site	347
A-24	Benthic macroinvertebrate cluster groups in the Osage River Basin	355

LIST OF FIGURES

Figure		Page
0	Geographic regions drained by the Osage River and its tributaries (McBride 1977)	3
1.	The location of the Osage River and its tributaries in Missouri	7
2.	A schematic drawing of an artificial substrate sampler "set." In situ (left). Being retrieved (right)	17
3.	Invertebrate sampling sites on the eastern Osage River Basin	18
4.	Invertebrate sampling sites on the southwestern Osage River Basin	19
5.	Invertebrate sampling sites on the northwestern Osage River Basin	20
6.	Community structure of benthic invertebrates by abundance and taxa for samples from the mainstem Osage River above Bagnell Dam, 1975-1976.	27
7.	Benthic invertebrate community characteristics for samples from the mainstem Osage River above Bagnell Dam, 1975-1976	28
8.	Benthic invertebrate community characteristics for samples from the mainstem Osage River below Bagnell Dam, 1975-1976	34
9.	Community structure of benthic invertebrates by abundance and taxa for samples from the mainstem Osage River below Bagnell Dam, 1975-1976	35
10.	Benthic invertebrate community characteristics for samples from the Maries and Little Maries rivers, 1975-1976	44
11.	Community structure of benthic invertebrates by abundance and taxa for samples from the Maries and Little Maries rivers, 1975-1976	45
12.	Community structure of benthic invertebrates by abundance and taxa for samples from Tavern and Gravois Creeks, 1975-1976	54

LIST OF FIGURES (cont.)

Figure		Page
13.	Benthic invertebrate community characteristics for samples from Tavern and Gravois creeks, 1975-1976	55
14.	Benthic invertebrate community characteristics for samples from the Wet Auglaize, Mill, and Dry Auglaize creeks, 1975-1976	61
15.	Community structure of benthic invertebrates by abundance and taxa for samples from the Wet Auglaize, Mill, and Dry Auglaize creeks, 1975-1976	62
16.	Community structure of benthic invertebrates by abundance and taxa for samples from Deer, Turkey, Big Buffalo and Cole Camp creeks, 1975-1976	69
17.	Benthic invertebrate community characteristics for samples from Deer, Turkey, Big Buffalo, and Cole Camp creeks, 1975-1976	70
18.	Benthic invertebrate community characteristics for samples from Clear, Weaubleau, and Monegaw creeks, 1975-1976	79
19.	Community structure of benthic invertebrates by abundance and taxa for samples from Clear, Weaubleau, and Monegaw creeks, 1975-1976	80
20.	Benthic invertebrate community characteristics for samples from the Marais des Cygnes River and Miami Creek, 1975-1976	89
21.	Community structure of benthic invertebrates by abundance and taxa for samples from the Marais des Cygnes River and Miami Creek, 1975-1976	90
22.	Benthic invertebrate community characteristics for samples from the Marmaton and Little Osage rivers, 1975-1976	102
23.	Community structure of benthic invertebrates by abundance and taxa for samples from the Marmaton and Little Osage rivers, 1975-1976	104

LIST OF FIGURES (cont.)

Figure | Page

24. Benthic invertebrate community characteristics for samples from the mainstem South Grand River and East Branch, 1975-1976 117

25. Community structure of benthic invertebrates by abundance and taxa for samples from the mainstem South Grand River and East Branch, 1975-1976 119

26. Benthic invertebrate community characteristics for samples from Big, Deepwater, and Bear creeks, 1975-1976 129

27. Community structure of benthic invertebrates by abundance and taxa for samples from Big, Deepwater, and Bear creeks, 1975-1976 130

28. Benthic invertebrate community characteristics for samples from Tebo Creek and tributaries, 1975-1976 139

29. Community structure of benthic invertebrates by abundance and taxa for samples from Tebo Creek and tributaries, 1975-1976 140

30. Benthic invertebrate community characteristics for samples from the mainstem Sac River, 1975-1976 152

31. Community structure of benthic invertebrates by abundance and taxa for samples from the mainstem Sac River, 1975-1976 153

32. Benthic invertebrate community characteristics for samples from the mainstem Little Sac River, 1975-1976 163

33. Community structure of benthic invertebrates by abundance and taxa for samples from the mainstem Little Sac River, 1975-1976 165

34. Benthic invertebrate community characteristics for samples from west flowing intergrade tributaries of the Sac River, 1975-1976 172

35. Community structure of benthic invertebrates by abundance and taxa for samples from west flowing intergrade tributaries of the Sac River, 1975-1976 174

LIST OF FIGURES (cont.)

Figure		Page
36.	Benthic invertebrate community characteristics for samples from east flowing intergrade tributaries of the Sac River, 1975-1976	181
37.	Community structure of benthic invertebrates by abundance and taxa for samples from east flowing intergrade tributaries of the Sac River, 1975-1976	183
38.	Benthic invertebrate community characteristics for samples from prairie tributaries of the Sac River, 1975-1976	189
39.	Community structure of benthic invertebrates by abundance and taxa for samples from prairie tributaries of the Sac River, 1975-1976	191
40.	Benthic invertebrate community characteristics for samples from the mainstem Pomme de Terre River and Lindley Creek, 1975-1976	201
41.	Community structure of benthic invertebrates by abundance and taxa for samples from the mainstem Pomme de Terre River and Lindley Creek, 1975-1976	202
42.	Benthic invertebrate community characteristics for samples from the Niangua, Bennett Spring, and Little Niangua rivers, 1975-1976	216
43.	Community structure of benthic invertebrates by abundance and taxa for samples from the Niangua, Bennett Spring, and Little Niangua rivers, 1975-1976	217

ABSTRACT

Aquatic invertebrates were collected from 85 sampling sites established on the Osage River and its major and minor tributaries to evaluate the water quality in these streams. Invertebrates were collected quarterly, beginning in the summer of 1975 and continuing through the spring of 1976. Water quality conditions in these streams were determined by examining the invertebrate communities at each site, both qualitatively and quantitatively. Qualitatively, the total number of taxa collected throughout the year and the number of mayfly and stonefly taxa found on a seasonal and annual basis were compared to standards for unpolluted Missouri streams. The invertebrate community structure and presence or absence of pollution sensitive taxa were also used as qualitative indicators of water quality. Quantitatively, the diversity of the invertebrate community was evaluated by calculating species diversity index values and comparing these values with standards for unpolluted Missouri streams. Invertebrate community structure between sites was compared by calculating coefficients of similarity for pairs of sites Sites with similar communities were grouped using cluster analyses. These calculations were helpful in assessing water quality in a particular stream or stream reach.

Point sources of pollution were identified and their specific impacts upon the receiving stream were documented. Non-point pollution sources were also identified. Poorly treated sewage effluent was the major point source of pollution in the Osage River Basin. Agricultural erosion and acid mine drainage were the most obvious non-point problems. Reservoir construction and channelization in the basin has also caused degradation.

Point and non-point pollution has seriously degraded a minimum of 293 miles of stream within the Osage River Basin, or about 3% of the original stream mileage. Channelization has irreversibly affected another 93 miles, and the construction of four large reservoirs totaling 143,800 acres have inundated another 1,658 miles. In total, nearly 22% of the streams in the Osage River Basin which are order 2 or larger, have been affected by these activities. The amount of disturbance ranged from 76% of the mainstem Osage River to about 5% of the streams in the Niangua River Basin.

That portion of the Osage River Basin in Missouri was divided into three zones, based on geographically land uses. Prairie streams draining the Western Plains Province were primarily affected by non-point pollution and channelization. The effects of point source discharges on these streams were generally masked by the non-point problems. Reaches of streams draining the Ozark Highland Province on the other hand were degraded by point sources. Non-point problems and channelization were virtually non-existent in this zone. The area drained by the Sac River was an area of transition or intergrade zone between the Ozarks and prairies. Likewise, degraded portions within this sub-basin were generally affected by a combination of point and non-point pollution. Stream habitat loss due to reservoir construction was evenly distributed throughout the Osage River Basin.

This survey documented the water pollution problems within the Osage River Basin and provided baseline information on the general water quality conditions. Hopefully, this information can be used to protect the 75% of the Osage River and its tributaries in which the influence of human activity is still minimal.

INTRODUCTION

Water quality surveys designed to collect baseline biological information have been completed on 14 river systems in Missouri since 1961. The objective of these surveys has been to determine existing water quality conditions, locate pollution sources, and obtain background information to evaluate the present and future effects of stream pollution upon these rivers and their tributaries. Surveys of the Meramec, Bourbeuse, and Big; Elk, James, and Spring; North, Salt, and Cuivre; and Current, Jack's Fork, Eleven Point, Little Black, and Warm Fork of the Spring rivers have been completed.

The Osage River Basin was chosen as the next study area because significant portions of this river and its tributaries would be lost to flooding after the completion of Harry S. Truman Reservoir. The information gathered will establish a basis to determine what, if any, damage occurs as a result of future municipal and industrial development. This would ensure protection of the water quality in this river system. Streams in the Osage River Basin consist of Ozark, prairie, and intergrade types. Very little is known about the benthic invertebrate fauna of the latter two stream types in Missouri. Information gathered during this survey would give an insight into the fauna present in unpolluted prairie and intergrade streams. This would aid in the establishment and enforcement of regulations to prevent further deterioration of water quality in the Osage River Basin and other prairie streams.

The U.S. Geological Survey and other agencies had already initiated physical and chemical surveys of the Osage River and its tributaries. This information coupled with benthos information provides a comprehensive assessment of the water quality in the Osage River Basin in Missouri.

STUDY AREA

Geography and Physiography

According to McBride (1977), the Osage River and its tributaries drain two geographic provinces in Missouri: the Western Plains and Ozark Highland (Fig. 0). Major streams draining the Western Plains Province are the South Grand, Marais des Cygnes, Little Osage and Marmaton rivers.

In general, these streams and their tributaries have had chronic water quality problems associated with excessive concentrations of suspended sediment, bacteria, nutrients, and agricultural chemicals. These problems are primarily brought about by excessive surface runoff and erosion (U.S. Department of Agriculture 1978). Collier (1959) indicated that, geographically, the Western Plains Province occupies an intermediate position between the glaciated Northern Plains Province to the north and the Ozark Highland Province to the south and east (Fig. 0). Much of the Western Plains Province is actually smoother and less rolling than either of its bordering provinces. The soils, and consequently the productivity of this province, are of low quality when compared to the glacial and loess soils of the Northern Plains Province, but superior to those of the Ozarks.

Terrestrial vegetation in the Western Plains Province is primarily prairie forms. About 14% of this area is forested with an oak-hickory association found on the uplands and an elm-ash-cottonwood association in the river bottoms (U.S. Department of Agriculture 1978). Streams in this province are typically turbid during most of the year with bottom substrate consisting primarily of finer materials such as silt, shale fragments, or organic debris. Gravel substrate is much less common than in the Ozark Highland Province.

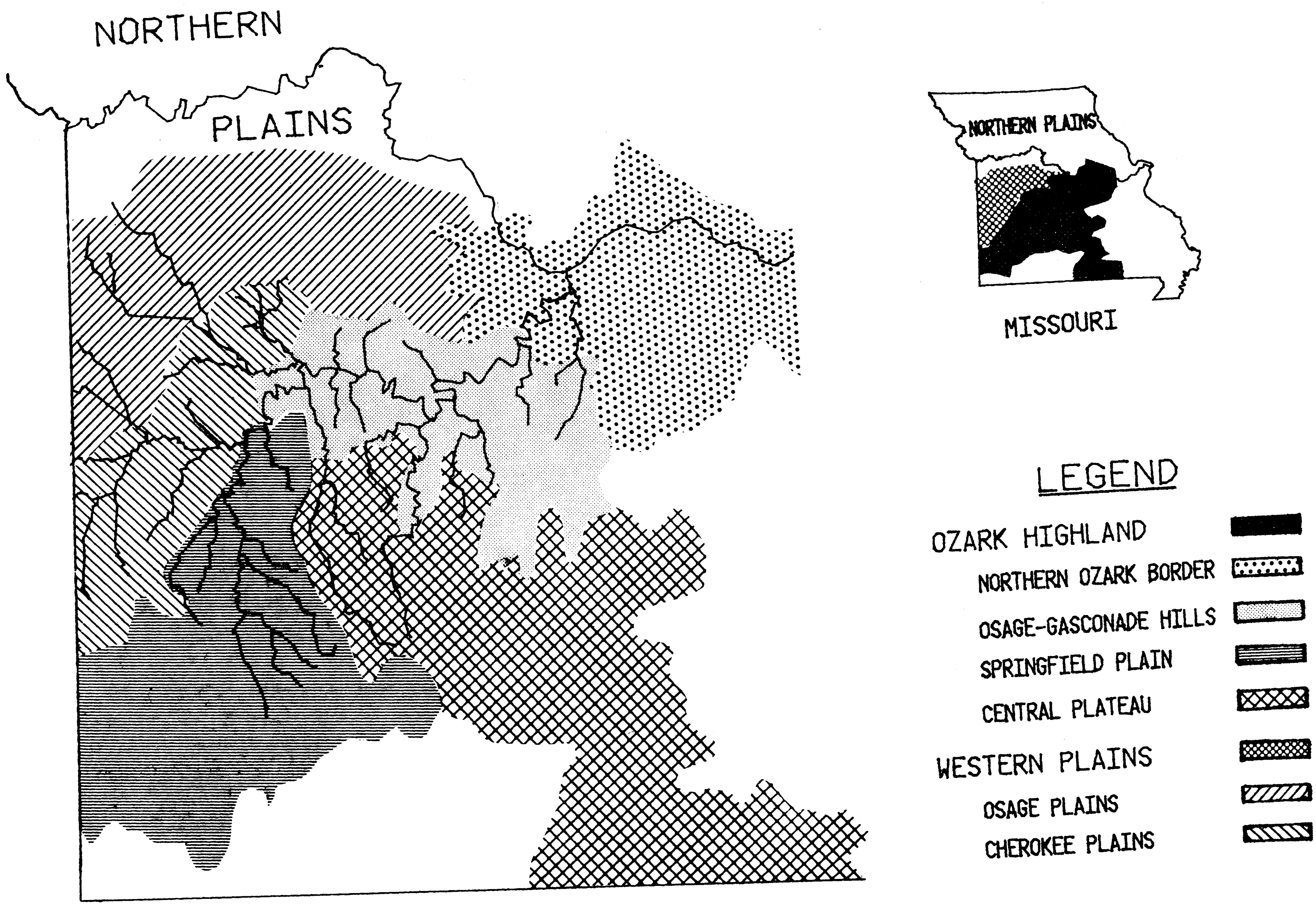


Figure 0. Geographical regions drained by the Osage River and its tributaries (McBride 1977).

Collier (1959) and others divide the Western Plains Province into two regions: the Osage Plains and Cherokee Plains (Fig. 0). Differential erosion of limestone, sandstone and shale strata in the Osage Plains Region has created a more rolling topography than the predominantly shale area of the Cherokee Plains Region. Agriculture is the major land use in both regions with over one-half of the total area in cropland (Austin 1972). Coal is the only important mineral resource in the Western Plains Province with surface mining being the primary method of removal. Most mining occurs in the Cherokee Plains Region (Barton and Vernon counties) since the overburden is much thinner than in the Osage Plains Region (Collier 1959). Some streams in both regions have been degraded by past mining practices.

In contrast to the Western Plains Province, the Ozark Highland Province is characterized by extensive areas of rough, hilly land, cherty soils, low agricultural productivity, and extensive forest lands. Four regions in this province are drained by the lower Osage River and its north flowing tributaries. These regions are the Springfield Plain, Osage-Gasconade Hills, Northern Ozark Border, and the Central Plateau (Fig. 0). The basis for separation of these regions is their degree of dissection.

Although productivity is less than in the Western Plains Province, agriculture is still the principal occupation in the Ozark Highland Province. Emphasis, however, is placed on livestock production because of the rougher terrain and stony soils. Terrestrial vegetation in the Ozark Highland Province is primarily forest cover with the percentage in the counties varying from 40-80%. The oak-hickory association is the principal forest type found. Since livestock grazing is the primary land use form, forest conversion to pastureland by spraying and bulldozing is rapidly increasing (U.S. Department of Agriculture 1978).

Streams flowing across the Ozarks Highland Province are generally clear and have substrates consisting of limestone fragments and chert. These cherty fragments are particularly important because they vary greatly in shape and size and therefore, pack loosely. This produces large interstitial spaces which allow large quantities of water to pass through the stream bed and provide excellent habitat for production of aquatic organisms (Clifford 1966).

The Springfield Plain Region, primarily drained by the Sac River, is considered to be the most productive of these four regions followed by the Northern Ozark Border Region. The former region is the only region in the Ozark Highland Province which has significant mineral resources and mining activities (Collier 1959). Most of these activities, however, do not occur in the Osage River Watershed.

Since most of the Ozark Highland Province are not cultivated, tributaries to the Osage River which drain this province do not have chronic water quality problems with suspended sediment and agricultural chemicals as do streams in the Western Plains Province. Erosion and sedimentation from forest conversion to pastureland and overgrazing, as well as forms of pollution associated with municipal sewage and industry, however, do cause problems in these four regions. Degradation of surface waters when it occurs, is readily apparent in this province since the streams are clear and support diverse aquatic communities. Of equal importance is the protection of subsurface waters in this province. The soluble limestone bedrock which underlies much of these regions provides easy access for surface water and pollution to the groundwater aquifers.

Osage River and Major Tributary Descriptions

Osage River

The Osage River originates in Missouri at the confluence of the Marais des Cygnes and Marmaton rivers in north-eastern Vernon County. The Marais des Cygnes River, upstream from this point, has always been considered the mainstem of the "Osage River" (Atkenson 1918). The Marmaton River and its tributary, the Little Osage River, are classified as lesser tributaries.

The Osage River flows eastward for about 280 miles across the Cherokee Plains, Osage-Gasconade Hills, and the Northern Ozark Border regions before entering the Missouri River near Jefferson City, Missouri (Fig. 0). At its mouth, the Osage River drains 16,538 square miles (Stout and Hoffman 1973) and has had an average discharge of 9,838 cubic feet per second (cfs) at St. Thomas, Missouri during the last 49 years (U.S. Geological Survey 1980). Vineyard and Feder (1974) list 93 springs which discharge into tributaries of the Osage River. All springs are found in the Ozark Highland Province (Fig. 0).

During historical times, the Osage River was used primarily for navigation. It was navigable during normal flow by "light draft" boats to Warsaw, Missouri (Anonymous 1889). In 1855, the United States Congress appropriated $50,000 for the construction of locks and dams to "improve" the Osage River for navigation (Anonymous 1889). Navigation on this river beyond Tuscumbia, Missouri ceased in 1931 with the closing of Bagnell Dam which created Lake of the Ozarks (55,500 acres). Since then, Pomme de Terre Reservoir, 1961 (7,800 acres); Stockton Reservoir, 1969 (24,900 acres); and Harry S. Truman Reservoir, 1978 (55,600 acres) have been constructed on the Osage River or its major tributaries in Missouri (Fig. 1). Collectively,

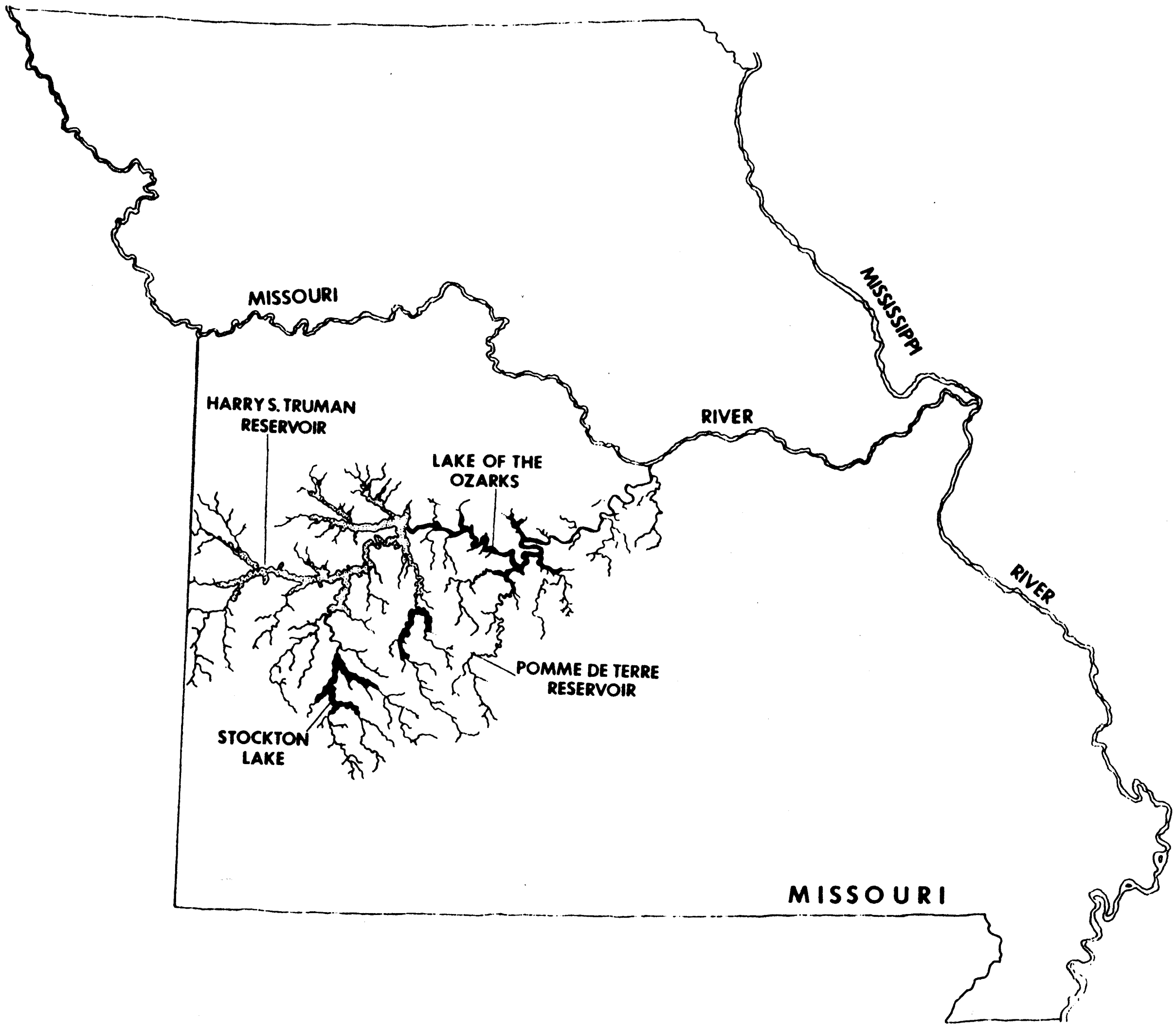


Figure 1. The location of the Osage River and its tributaries in Missouri.

these four reservoirs have permanently inundated 602 miles of river, representing 21% of the larger stream habitat (stream order 4 or greater) in the Osage River Basin (Missouri Department of Conservation 1979). These modifications, coupled with the alteration of 93 miles by channelization, the pollution of 293 miles by point and non-point sources, the periodic inundation of 324 miles at flood pool for these reservoirs, and the undetermined affects of excessive concentrations of suspended sediment, nutrients, and pesticides from streams draining the Western Plains Province have drastically changed this basin (Missouri Department of Conservation 1978). All totaled, a minimum of 21% or 2,044 miles of stream in the Osage River Basin, has been modified by human activities.

Marais des Cygnes River

The Marais des Cygnes River originates in east central Kansas and flows southeast for about 235 miles before joining the Marmaton River in southeastern Bates County. The majority of its course is in Western Plains Province with the lower 30 miles flowing across the Osage Plains Region (Fig. 0). The Marais des Cygnes River drains 3,230 square miles at the Missouri-Kansas boundary, and has an average discharge of 1,984 cfs over the past 20 years (U.S. Geological Survey 1978). Three headwater, flood control reservoirs have been constructed on the Marais des Cygnes River by the U.S. Army Corps of Engineers in Kansas. They are Melvern, Pomonia, and Hillside (under construction). A fourth reservoir, Garnett, was placed on the inactive list in 1974 but remains authorized (U.S. Army Corps of Engineers 1979a). Between 1906 and 1911, all but 6 miles of the Marais des Cygnes River in Missouri were channelized to create the Bates County Drainage Ditch (Atkenson 1918). This was done to improve the agricultural productivity

of the bottomland. Half of the land use in the Western Plains Province is agriculture (Austin 1972). It is unfortunate that a stream which had produced 126 pound flathead catfish, had to be sacrificed (Atkenson 1918).

Coal is the primary mineral resource in the Western Plains Province. Much has been mined in the Mulberry Creek Watershed, a south flowing tributary to the Marais des Cygnes River. Surface mining was restricted to this area since the thicker overburden found in the Osage Plains Region made this form of mining too expensive (Collier 1959). This surface mining plus the influence of point pollution discharges have caused chronic water quality problems in this basin from excessive concentrations of suspended sediment, dissolved metals, nutrients, and agricultural chemicals.

Marmaton - Little Osage Rivers

The Marmaton River and its major tributary, the Little Osage River, are considered to be secondary tributary streams forming the Osage River. The Marmaton River begins in Allen County, Kansas and flows eastward for 107 miles before joining the Marais des Cygnes River and forming the Osage River (Fig. 0). Of the 107 total miles, 47 miles are in Missouri. The Marmaton River drains 292 square miles at Marmaton, Kansas and has had an average discharge of 290 cfs over the past 7 years (U.S. Geological Survey 1978). One headwater, floodcontrol reservoir, Fort Scott, has been considered by the Corps of Engineers but was deferred for restudy in 1977 (U.S. Army Corps of Engineers 1979a).

The Little Osage River begins in Anderson County, Kansas and flows 87 miles to its confluence with the Marmaton River in north-central Vernon County (Fig. 0). The lower 31 miles of the Little Osage River lie within Missouri. Average discharge during the past 29 years in the Little Osage

River at Fulton, Kansas has been 208 cfs. The drainage basin at this location is 295 square miles (U.S. Geological Survey 1978). No major impoundments exist or are planned in this watershed at this time.

Both streams flow across the Cherokee Plains Region in Vernon County, Missouri (Fig. 0). Like in the Osage Plains Region, land use in this region is primarily agricultural with rowcrops occupying approximately one-half of the land surface. Coal mining in this region is more prevalent since the overburden is much thinner when compared to the Osage Plains Region (Collier 1959). Most areas in western Vernon County have active strip-mining in progress or have been mined in the past. To date, channelization has not been a problem in either river (Missouri Department of Conservation 1978).

The chronic problems caused by point and non-point pollution in the Marais des Cygnes River were also common in the Marmaton and Little Osage rivers.

South Grand River

The South Grand River is the second largest tributary to the Osage River. It originates in northwestern Cass County and is wholly contained within Missouri's border. It flows southeast for 130 miles and enters the Osage River near Warsaw, Missouri. The South Grand River drains 1,660 square miles at Brownington, Missouri and had an average flow of 1,046 cfs between 1921 and 1971 (U.S. Geological Survey 1971).

It is interesting to note that in 1883 the people in this area felt that the waterways in this basin needed no improvements. These waterways were considered well dispersed and distributed and could not possibly be improved by man (Anonymous 1883). Today, conservation pool of Harry S.

Truman Reservoir permanently inundates approximately the lower one-half of the South Grand River. About 34 miles of the South Grand and Big Creek which are not inundated by the reservoir have already been channelized (Missouri Department of Conservation 1978).

Basically, the South Grand River flows across the Western Plains Province, however, three geological regions are involved. The portion upstream from the mouth of its major tributary, Big Creek, flows across the Osage Plains Region. From the mouth of Big Creek to the mouth of Deepwater Creek, the South Grand River flows across the Cherokee Plains Region. The lower 20-25 miles borders the Osage-Gasconade Hills Region of the Ozark Highland Province (Fig. 0).

Land use practices in the South Grand River Basin are primarily dependent on the geographic region involved. Land use along reaches of the South Grand River which lie within the Osage Plains Region are dominated by agricultural practices. There is very little coal mining. The amount of coal mining increases along reaches (Tebo Creek) within the Cherokee Plains Region. Since the Western Plains Province includes most of this basin, point and non-point problems indicated for the previously discussed streams also apply to the South Grand River.

Permanent inundation of portions of the Osage, Marais des Cygnes, Marmaton, and South Grand rivers by Truman Reservoir eliminated most of the known spawning grounds for the paddlefish (Polyodon spathula), a very important gamefish in Missouri (Russell, Graham, Carlson and Hamilton 1980; Pflieger 1971). A few areas have been found in unaffected portions of these rivers which are similar to known spawning grounds. To date, however, spawning has not been documented at these locations (Russell, Graham, Carlson and Hamilton 1980). Without sufficient natural reproduction or artificial

propagation and stocking, the present paddlefish populations in these streams will decline because of inundation of critical spawning habitat.

Sac River

The Sac River lies entirely within the Springfield Plain Region of the Ozark Highland Province (Fig. 0). It is the largest of the tributaries draining this province and third in size of all tributaries to the Osage River. The Marais des Cygnes and South Grand rivers are larger. The Sac River at Stockton, Missouri drains 1,160 square miles and had an average discharge of 987 cfs between 1921 and 1969 (U.S. Geological Survey 1969). At its mouth, it drains 1,970 square miles (Stout and Hoffman 1973). Vineyard and Feder (1974) list 51 springs in the Sac River Basin. The majority of these springs are located in the headwaters of the Sac and Little Sac rivers which lie northwest of Springfield, Missouri.

Although physical features of the Springfield Plain Region resembles the prairie regions of the Western Plains Province, it is the western border region of the Ozark Highland Province (Collier 1959). This region is a transition zone between the rolling prairies and rugged Ozarks. Its surface is smooth except near larger streams which are bordered by strips of hilly land. Therefore, the relief over much of the region is less and the soil conditions are more productive than the rest of the Ozark Highland Province (Sauer 1920). Livestock is the primary form of agriculture in this region. Mineral resources and mining activities are significant. The production of lead, zinc, tripoli, and marble are of prime importance in the region (Collier 1959). The major form of mining in the Sac River Basin, however, is for gravel and quarry stone.

Water quality problems in the Sac River Basin are primarily associated

with point sources of pollution (Missouri Department of Conservation 1978). The contruction of Stockton Reservoir in 1969 permanently inundated 141 miles of the Sac and Little Sac rivers and their tributaries. This represents 8% of the stream mileage in this basin. Erosion and flooding problems exist in the Sac River downstream from Stockton Dam. These problems are associated with hydroelectric generation periods. The completion of Truman Reservoir in 1978 permanently flooded an additional 9 miles of the Sac River at its mouth. Flood pools of these two reservoirs periodically inundate an additional 91 miles.

Pomme de Terre River

The Pomme de Terre River originates in Webster County and flows north across the Central Plateau and Osage-Gasconade Hills regions (Fig. 0). It drains 615 square miles at Hermitage, Missouri and had a 40 year average discharge of 620 cfs prior to the closing of Pomme de Terre dam in 1961 (U.S. Geological Survey 1961). Since that time, the average discharge has been 457 cfs (U.S. Geological Survey 1980). Seven springs discharge into the Pomme de Terre River (Vineyard and Feder 1974).

Pomme de Terre Reservoir was built for flood control and has a low level discharge outlet. The periodically lower quality and quantity of discharge concerns local residents and has caused a noticeable decline in the fishery in reaches downstream from the dam (Personal Communication, 1975, Steven Q. White, Conservation Agent, Missouri Department of Conservation, Hermitage, Missouri).

Most of the Pomme de Terre River flows across the Central Plateau Region of the Ozark Highland Province. Up to three fourths of its watershed is in farm and three-fourths of that is forested. The soil in this and the Osage-

Gasconade Hills regions contains large quantities of chert, so the agricultural emphasis is on livestock production (Collier 1959). There are few mineral resources in these regions and manufacturing is poorly developed. Forest products are used but to a lesser degree than in other regions (Collier 1959).

Most streams in this basin have little or no water quality problems when compared to the streams in the Western Plains Province. What problems do exist are associated with point sources of pollution (Missouri Department of Conservation 1978).

Niangua River

The Niangua River also begins in Webster County and flows north across the Central Plateau and Osage-Gasconade Hills regions (Fig. 0). It had a 40 year average discharge of 627 cfs at Decaturville, Missouri between 1929 and 1969 (U.S. Geological Survey 1969). It drains 1,040 square miles at its mouth (Stout and Hoffmann 1973). Thirteen springs are reported in the Niangua River Basin by Vineyard and Feder (1974). Two of these rank within the top 15 springs in Missouri. Both discharge into the mainstem Niangua River (Bennett, 4th, 155 cfs and Hahatonka, 12th, 74 cfs).

Land uses in the Niangua River Basin are similar to those mentioned for the Pomme de Terre River. Both streams are typical Ozark Highland Province streams which are clear, have good substrate for the production of aquatic life, and are important recreation areas. The major problems in the Niangua River and its tributaries, when they exist, are caused by point sources of pollution (Missouri Department of Conservation 1978).

MATERIALS AND METHODS

Field and Laboratory Procedures

Water quality conditions were evaluated in the Osage River and its tributaries by studying the benthic invertebrate communities. Benthic organisms are relatively immobile and cannot quickly avoid harmful changes in water quality. Their presence, absence, abundance, and community composition reflects environmental conditions of the recent past (Chandler 1970). The community structure with reference to specific benthic invertebrate groups or taxa also provides a measure of water quality, since invertebrates have different degrees of pollution tolerance (Gaufin 1958). Thus, the effect of pollutants entering a stream may be determined by sampling the invertebrate community and comparing it, qualitatively and quantitatively, with unaffected communities and criteria established for unpolluted Missouri streams.

This survey was initiated by contacting field personnel employed by the Missouri Department of Natural Resources, Division of Environmental Quality and the Missouri Department of Conservation to identify all known sources of pollution and locate suitable sampling sites. A list of known pollution discharges and potential pollution problems was prepared from these contacts and by reviewing a water quality management plan for the Osage River Basin (Missouri Department of Natural Resources 1976). This list is presented in Table 1 and is current through December 1976. No portion of Lake of the Ozarks, Pomme de Terre, and Stockton reservoirs were sampled since this survey was concerned with the flowing reaches of the Osage River Basin. A few sites were selected in portions of the Osage River and its tributaries that were to be inundated by Harry S. Truman Reservoir. The majority of sites, however, were located just upstream from projected flood pool elevations.

Benthic invertebrate samples were collected during January, April, July and October using a modification of the Surber sampling technique and artificial substrates (Fig. 2). In all, 85 sampling sites were established on the Osage River and its major and minor tributaries (Figs. 3-5, Table 2). Sampling was initiated in July 1975 and completed by June 1976. Qualitative sampling for naiads (mussels) was included during each benthos sampling trip. A list of fish species known to occur in the survey streams was compiled from Pflieger (1975).

Sections of the Osage River and its tributaries which had permanent, stable riffles were sampled by disturbing the substrate to a depth of 4-6 inches with a three-pronged digging tool. Dislodged organisms were collected in a Turtox # 105T33 heavy nylon bottom net (20 mesh per inch) placed immediately downstream from the disturbed area. Between 8-16 square feet of riffle substrate were sampled during each collection at each site during the survey.

Sampling sites that lacked riffle areas were sampled by installing three "sets" of artificial substrates at each site. Each "set" consisted of a 7x7x11 inch wire basket filled with 2-4 inch limestone rocks and a modified multiple-plate sampler (Fig. 2) described by Hester and Dendy (1962). Each "set" was allowed to colonize for at least 6 weeks.

Debris and invertebrates collected in the bottom net and artificial substrates were placed into two screened pans for washing. The upper pan had 2 mesh per inch hardware cloth screen and the lower pan a 50 mesh per inch stainless steel wire screen. Debris remaining in the upper screen was checked for organisms and discarded. Organisms from the upper screened pan and all material from the lower pan were preserved in 10% formalin. Samples were transported to the laboratory where the preservative was

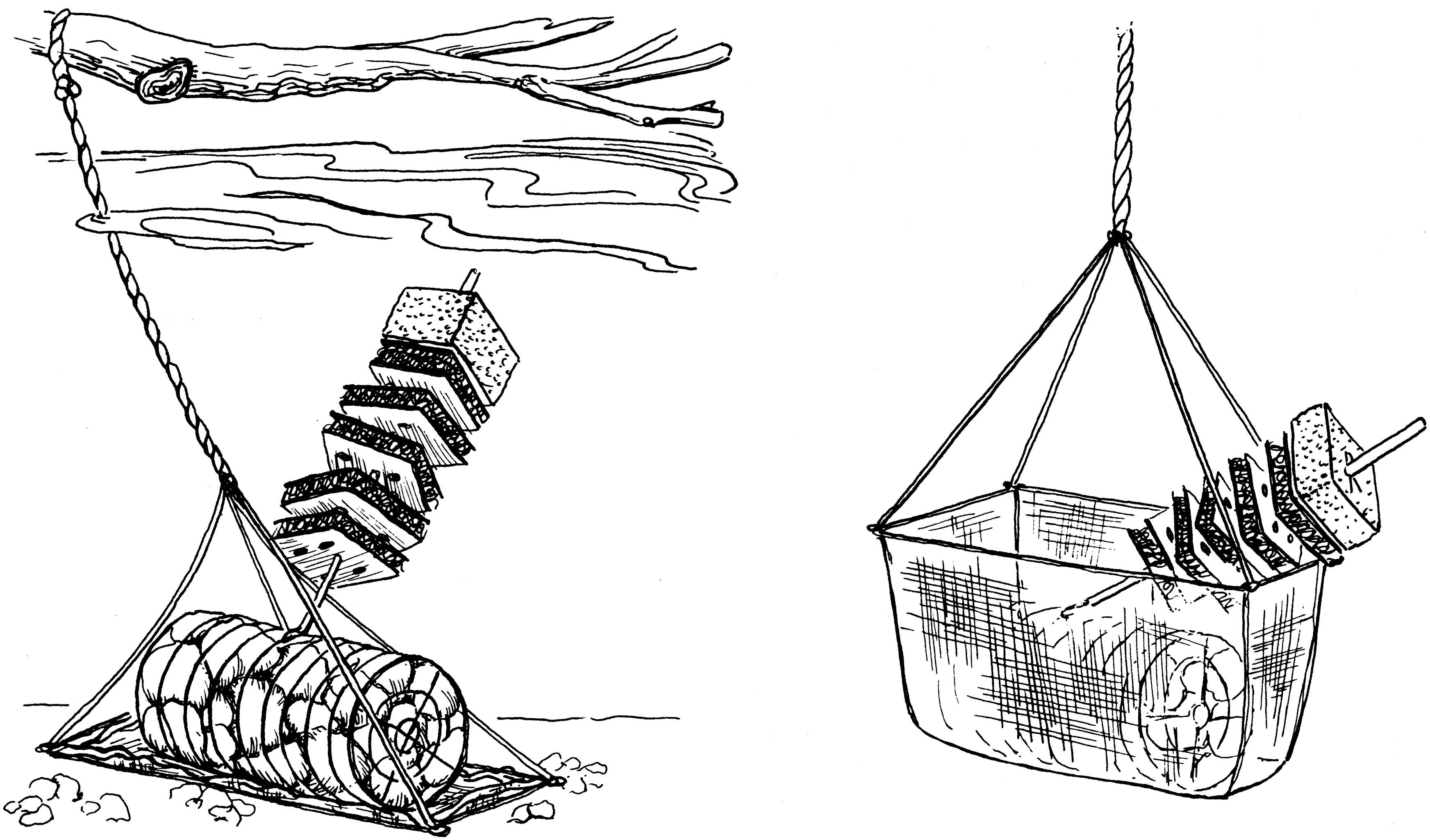


Figure 2. A schematic drawing of an artificial substrate sampler "set". _In situ_ (left). Being retrieved (right).

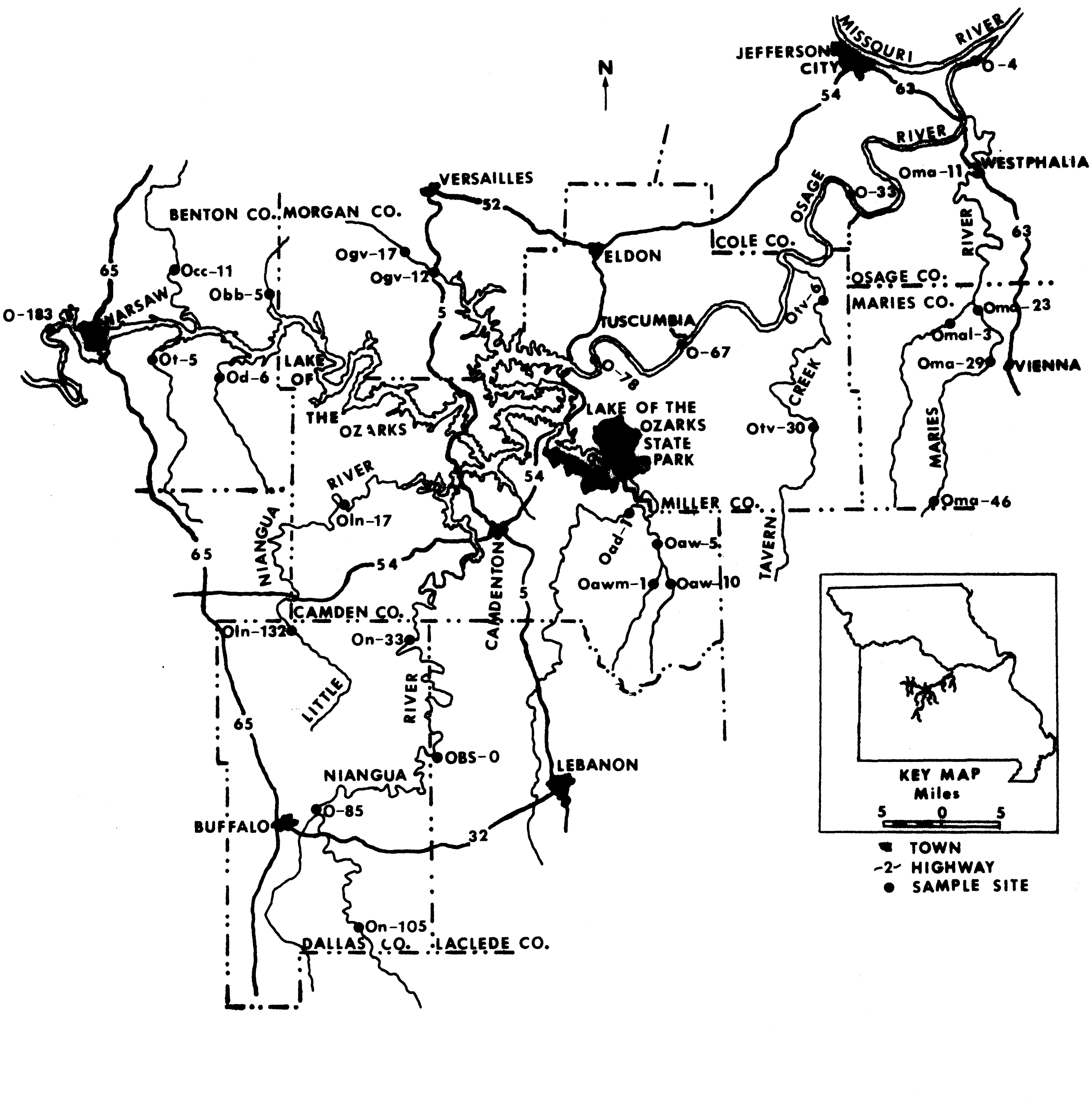


Figure 3. Invertebrate sampling sites on the eastern Osage River Basin.

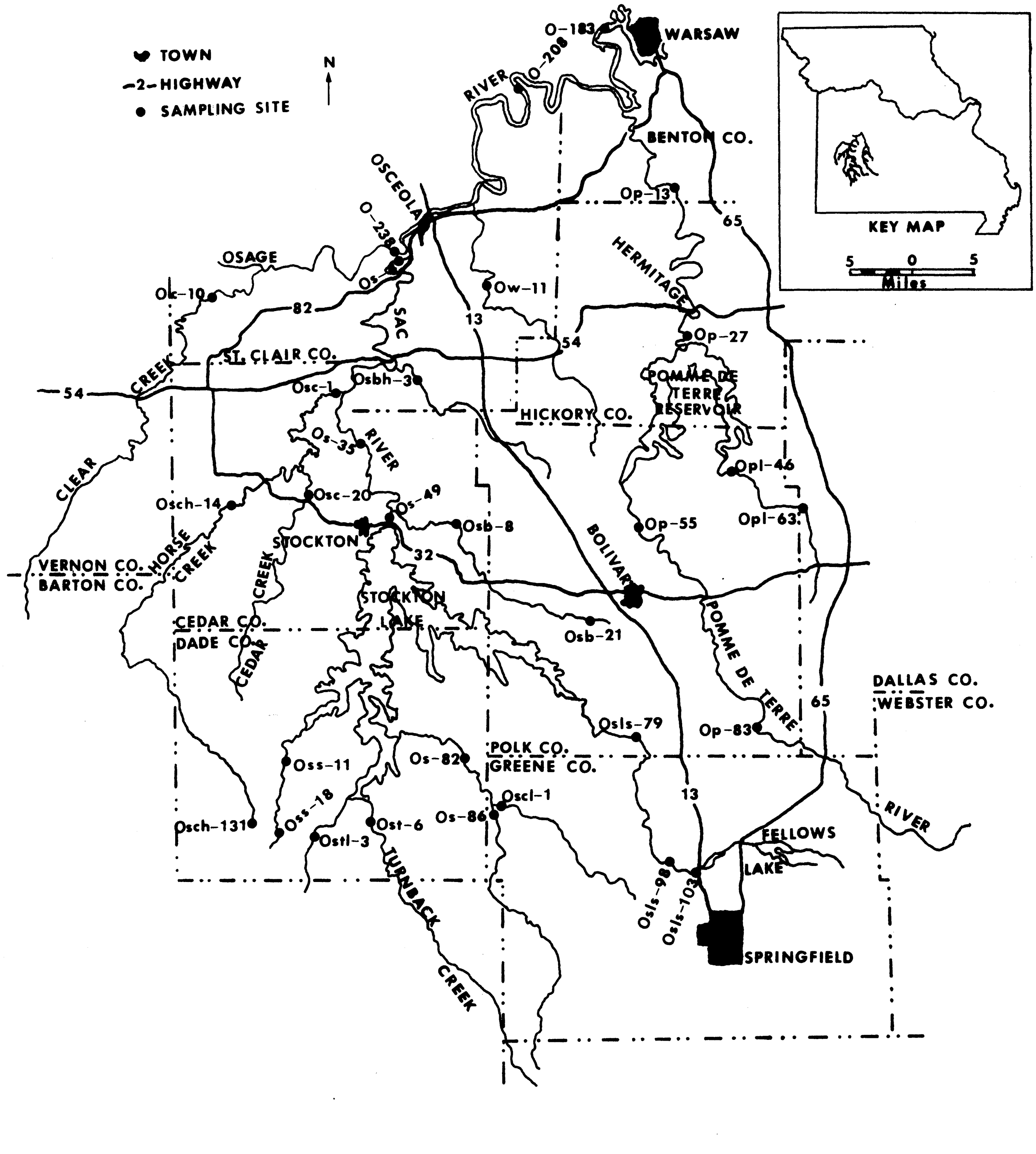


Figure 4. Invertebrate sampling sites on the southwestern Osage River Basin.

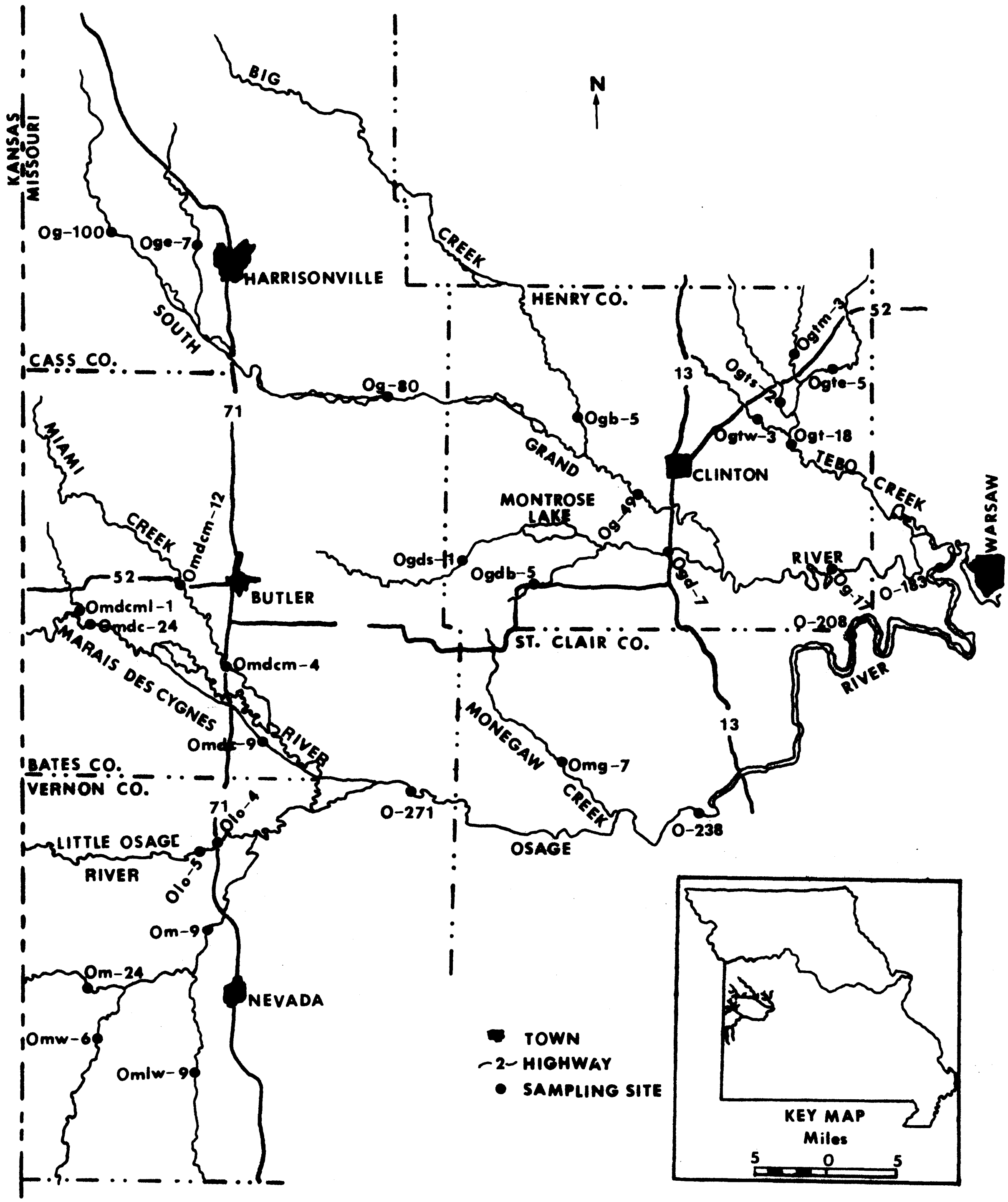


Figure 5. Invertebrate sampling sites on the northwestern Osage River Basin.

changed to 70% ethanol to minimize the brittleness which occurs from long-term storage in formalin.

Samples to be sorted were washed with water in an U.S. No. 35 Standard Seive to remove the preservative. Most organisms were removed from the debris by a sugar flotation method described by Anderson (1959). Debris was also systematically hand sorted to assure removal of all invertebrates not suspended during sugar flotation. Organisms were represerved in 70% ethanol for identification.

Identification of invertebrates was accomplished using compound and binocular dissecting microscopes and the following references: Beck (1976); Borror and DeLong (1971); Burks (1953); Curry (1958); de la Torre-Bueno (1937); Frison (1935, 1942); Grabau (1955); Hilsenhoff (1970, 1975); Johannsen (1934); Lewis (1974); Merritt and Cummins (1978); Peterson (1960, 1962); Ross (1944); Ross and Horsfall (1965); U.S. Environmental Protection Agency (1972); Usinger (1963); Ward and Whipple (1959); Wiggins (1977); Williams (1954).

Benthic organisms were identified to the following taxonomic levels:

(1) Flatworms (Platyhelminthes), roundworms (Nematoda), and segmented worms (Annelida) were identified to class.

(2) Flies (Diptera) were identified to family or genus.

(3) Mayflies (Ephemeroptera), stoneflies (Plecoptera), caddisflies (Trichoptera), naiads (Pelecypoda), snails (Gastropoda), crustaceans, and other organisms were identified to genus or species.

Physical and chemical information was collected at selected sites throughout the Osage River Basin by the U.S. Geological Survey and the U.S. Army Corps of Engineers, Kansas City District. These data are summarized in Appendix Tables A1-A6.

Data Analysis

Water quality conditions at each site were assessed by comparing sample and annual benthic invertebrate community characteristics such as the number of mayfly and stonefly taxa, total number of taxa, and species diversity index values with criteria established for unpolluted Missouri streams (Table 3). Coefficients of similarity comparing invertebrate communities between sites also helped to determine the water quality conditions in each study stream. Annual characteristics for total taxa and the number of mayfly and stonefly taxa were determined for each sampling site by summing the different taxa collected in all samples at that site for the entire year.

Table 3. Water quality criteria for unpolluted Missouri streams.[1]

	Individual Sample		Pooled (Annual)		
Water quality designation	Species diversity index value	No. of mayfly and stonefly taxa	Species diversity index value	No. of mayfly and stonefly taxa	Total taxa
Unpolluted	>3.9	>9	>6.9	>21	>56
Moderately Polluted	2.2-3.9	5-9	3.8-6.9	10-21	31-56
Polluted	<2.2	<5	<3.8	<10	<31

1-Based on work done in Missouri by Dieffenbach and Ryck (1976), Duchrow (1974, 1976a, 1976b, and 1977), Kuester (1964), Ryck (1974, 1976a), and regression analysis of 895 samples.

Species diversity index values (d) were calculated for each collection date and annually for each site using the equation derived by Margalef (1957) and discussed in more detail by Wilhm (1967) and the U.S. Environmental Protection Agency (1973):

$$d = \frac{s-1}{\log_e N}$$

Where s equals the number of taxa and N the total number of organisms in the sample. In Missouri streams, diversity values have ranged from 0.0 (low) to 10.0 (high). Annual species diversity index values were calculated for each site using pooled values for s and N.

Coefficients of similarity (C) were used to compare benthic invertebrate communities between sites and as a basis for an unweighted paired group cluster analysis. The coefficient used was described by Burlington (1962) and was a modification of a dissimilarity coefficient developed by Bray and Curtis (1957) and discussed in Clifford and Stephenson (1975). The cluster analysis was described by Everitt (1974). Each coefficient comparing the invertebrate communities at two sites was calculated from the equation:

$$C = \frac{200W}{a + b}$$

Where a is the sum of prominence values for each type of organism at site 1, b is the sum of prominence values for each type of organism at site 2, and W is the sum of the prominence values for each type of organism the two sites had in common. A prominence value for each type of organism at any site was calculated by multiplying the square root of the organism's frequency of occurrence (the percent of sites at which the organism occurs) by its density (numbers per square foot) at that site. Coefficients of similarity greater than 50 are considered high, indicating that the sites being compared had similar invertebrate communities. Values less than 50 indicate decreasing similarity in the invertebrate communities being compared (Dieffenbach and Ryck 1976; Duchrow 1976a, 1976b, 1977, and 1978; Duchrow and Trial 1980; Duchrow, Robinson-Wilson and Trial 1980; Ryck 1976a). The unweighted paired group cluster analyses described by Everitt (1974) was used with these coefficients to group sites with similar community structures into clusters.

Water quality conditions in the Osage River and its tributaries were classified as polluted, moderately polluted, or unpolluted based on the comparison of these biological characteristics at each site with criteria established for Missouri streams and the physical and chemical conditions of the stream and its watershed.

RESULTS

Osage River Basin

A total of 113 fish species representing 22 families have been collected in the Osage River and its major and minor tributaries (Table 4). The wide variety of habitat types support fish species ranging from the small, endemic Niangua darter, *Etheostoma nianguae*, classified as rare in Missouri (Nordstrom, Pflieger, Sadler and Lewis 1974) to large, prized gamefish such as the largemouth bass, *Micropterus salmoides*, smallmouth bass, *M. dolomieui*, channel catfish, *Ictalurus punctatus*, and paddlefish, *Polyodon spathula*.

The benthic invertebrates in the Osage River Basin are equally diverse. A total of 254 taxa (types) of aquatic invertebrates including 60 mayfly and stonefly taxa were collected at the 85 sampling sites established throughout the Osage River Basin (Table 5). In stream reaches which were not highly influenced by human activities, pollution intolerant taxa from many invertebrate groups were well represented. Likewise, benthic invertebrate community characteristics generally met or exceeded the criteria for unpolluted Missouri streams listed in Table 3. As reaches of these prairie, intergrade or Ozark streams became polluted or otherwise affected, the invertebrate communities became less diverse and sensitive taxa were severely reduced or eliminated. Seasonal and annual benthic invertebrate community characteristics were also reduced. Although specific point source pollution had demonstrative effects

in certain watersheds, the overall degrading effects of soil erosion, stream channel modification, and other forms of non-point pollution were also observed during the survey.

Osage River (Mainstem)

The mainstem Osage River originates at the confluence of the Marais des Cygnes and Marmaton rivers in northeastern Vernon County (Fig. 5). From this beginning, it flows eastward for about 280 miles across the agricultural reaches of the Western Plains Province and the more rolling topography of the Ozark Highland Province. The mainstem Osage River enters the Missouri River 10 miles downstream from Jefferson City, Missouri. Seventy-one percent (200 miles) of lotic habitat along this course has been altered by two mainstem reservoirs, Lake of the Ozarks, 1931 (93 miles) and Harry S. Truman Reservoir, 1978 (107 miles). The remaining 80 miles represent a great variety of lotic habitat types which in turn support quite different communities of aquatic invertebrates. These differing habitat types are in part a result of the surrounding topography and are in some instances influenced by point and/or non-point pollution.

Pflieger (1975) listed 95 species of fish inhabiting the mainstem Osage River. This is the greatest number of species found in any of the major subdivisions within this basin (Table 4). A total of 132 taxa of aquatic invertebrates were collected at eight sampling sites established on the Osage River through its course (Table 5). Four of these sites were located between Bagnell Dam and the mouth (Fig. 3) and the remaining four were upstream from Truman Dam at Warsaw, Missouri (Fig. 5). These latter sites are presently inundated by that reservoir and the lotic communities sampled during 1975-76 no longer exist.

The uppermost site on the mainstem (0-271) was located 9 miles downstream from its origin (Fig. 5; Table 2). The Osage River at this site was too deep to sample with the riffle net during normal flow and was, therefore, sampled with artificial substrate samplers (Fig. 2). The substrate at 0-271 was primarily silt with a large amount of organic detritus. During very low flow, a stable shale substrate riffle was present at this site (October 1975). The benthic invertebrate community at 0-271 was considered to be typical of an unaffected prairie stream. Flies were the dominant taxonomic group at this site, however, pollution sensitive mayflies and caddisflies were also well represented (Fig. 6). The more abundant taxa in these dominant groups were:

Flies (48%)		Mayflies (18%)		Other (17%)	
Chironomidae	87%	*Stenacron interpunctatum*	46%	Oligochaeta	89%
Simuliidae	9%	*Stenonema pulchellum*	24%	*Argia apicalis*	2%
Chaoborus sp.	1%	*Isonychia* sp.	13%	*A. moesta*	2%

Caddisflies (16%)	
Potamyia flava	47%
Hydropsyche orris	19%
Cheumatopsyche sp.	10%

Water quality in the Osage River at this site did not appear to be adversely affected by upstream agricultural or mining practices and was considered unpolluted. Although annual benthic invertebrate community characteristics (Fig. 7, Appendix Table A-7) were only slightly below statewide criteria (Table 3), sample species diversity index values exceeded the minimum of 4.0 in three of four samples (Appendix Table A-7).

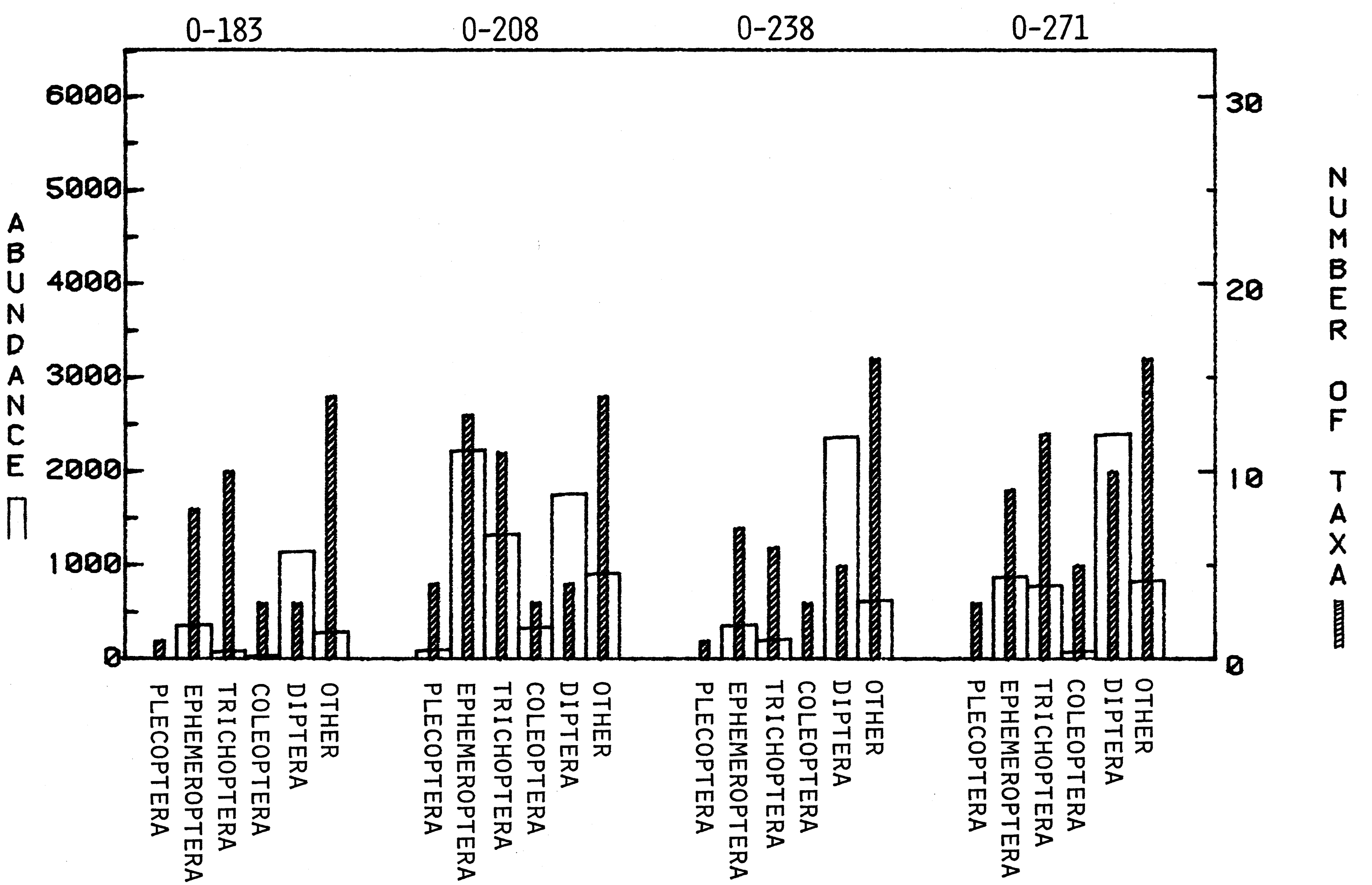


FIGURE 6. COMMUNITY STRUCTURE OF BENTHIC INVERTEBRATES BY ABUNDANCE AND TAXA FOR SAMPLES FROM THE MAINSTEM OSAGE RIVER ABOVE BAGNELL DAM- 1975-76.

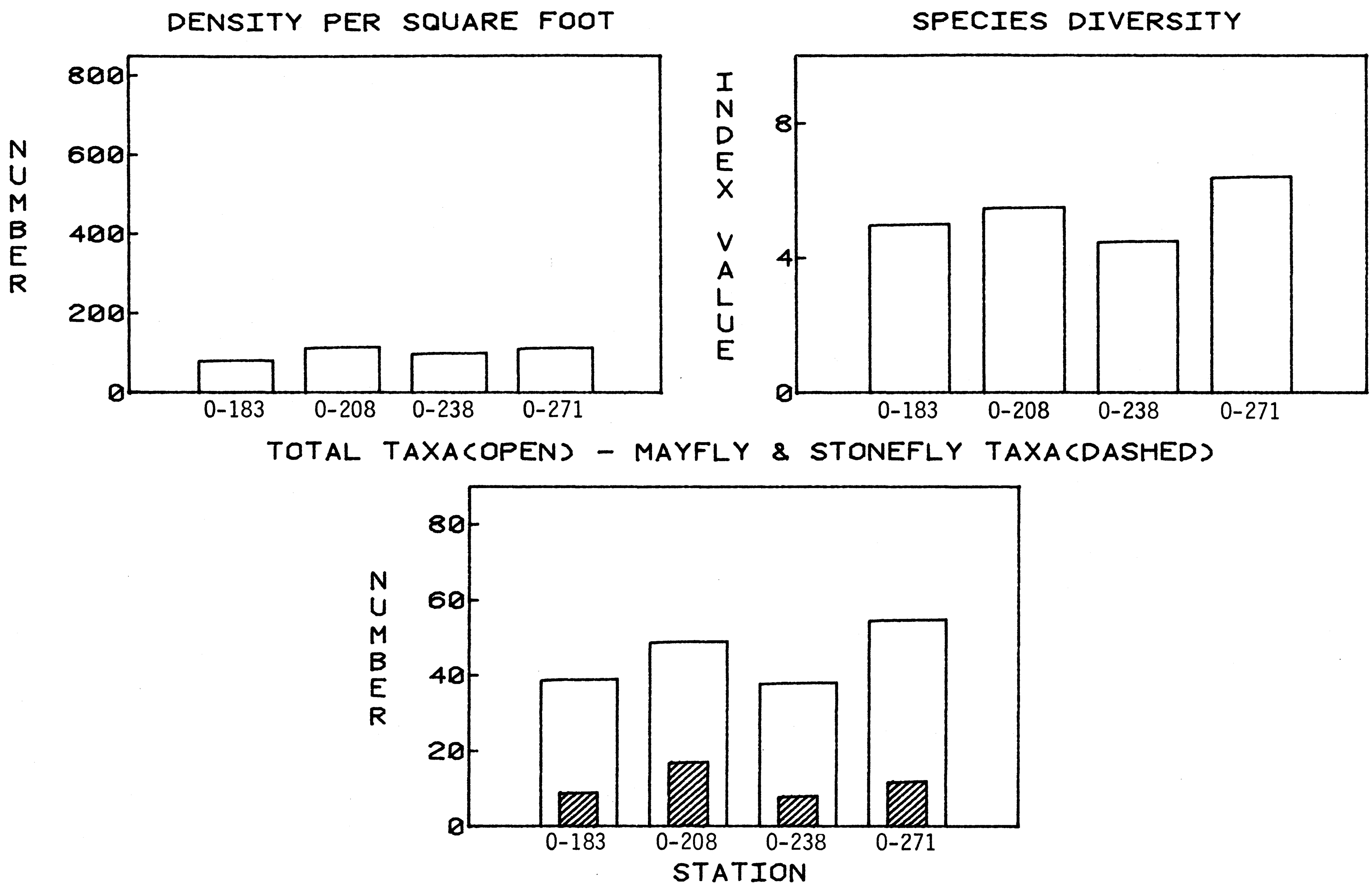


FIGURE 7. BENTHIC INVERTEBRATE COMMUNITY CHARACTERISTICS FOR SAMPLES FROM THE MAINSTEM OSAGE RIVER ABOVE BAGNELL DAM- 1975-76.

The invertebrate community structure at 0-271 was compared with those at other survey sites using coefficients of similarity. The results showed similarity with 17 sites (Appendix Table A-23) including four of the remaining seven mainstem sites (Appendix Table A-8).

Sampling site 0-238 was located on the mainstem Osage River about 0.5 mile upstream from the mouth of the Sac River (Fig. 5; Table 2). Substrate was primarily silt and contained only small quantities of organic detritus. Artificial substrate samplers were used to collect all four samples since water depth, sluggish flow and substrate type were not suitable for other sampling methods. The benthic invertebrate community characteristics for samples at this site were lower than at 0-271 (Fig. 7, Appendix Table A-7). These characteristics on a sample and annual basis were indicative of moderately polluted water quality (Table 3). The lack of suitable habitat from erosion and sedimentation was the probable reason for these depressed values. Although two small point discharges were identified in upstream tributaries (Table 1), it is doubtful if any effects of these could have been detected at this site.

The structure of the invertebrate community at 0-238 was quite similar to that at the preceding site, 0-271 (C=66; Fig. 6), except that the more sensitive mayflies and caddisflies were not as well represented. Flies made up 66% of the benthos collected, followed by aquatic worms and mayflies. Dominant taxa within these groups were:

Flies (66%)		Other (27%)		Mayflies (10%)	
Chironomidae	96%	Oligochaeta	59%	_Stenacron interpunctatum_	59%
Bezzia/ _Probezzia_, ...,	3%	_Argia apicalis_	2%	_Hexagenia limbata_	27%
Chaoborus sp.	<1%	Sphaeriidae	15%	_Leptophlebia_ sp.	3%
				Stenonema pulchellum	3%

The invertebrate community structure at 0-238 was similar to that at 16 other sites in the Osage River Basin (Appendix Table A-23). Ten of these sites also had invertebrate communities similar to the community at 0-271.

Aquatic habitat at 0-208, located about 25 miles downstream from Osceola, Missouri (Fig. 4; Table 2), was quite different than at the previous sites. A stable riffle consisting of varying sized fragments of chert and limestone rock was found at this site, similar to those found in the streams in the Osage-Gasconade Hills and the Central Plateau regions of the Ozark Highland Province (Fig. 0). Water clarity was moderately turbid as at previous sites, however, the number of pollution sensitive mayfly and stonefly taxa were the highest of samples collected from the eight mainstem Osage River sites (Fig. 7, Appendix Table A-7). Point source discharges from Lowrey City and a subdivision were identified in the watershed (Table 1). They discharged into tributaries of the Osage River, upstream from 0-208. Reported raw and treated sewage effluent from the city of Osceola also discharge directly into the mainstem. Effects of these discharges were not detected at 0-208 probably because of the far downstream distance of this site from the pollution. Seasonal and annual benthic invertebrate community characteristics (Fig. 7, Appendix Table A-7) bordered the criteria established for unpolluted Missouri streams listed in Table 3, and exceeded these criteria on a couple of occasions. The water quality at this site was considered unpolluted. Any effects of point or non-point sources of pollution were not of detectable magnitude during the survey.

Facultative mayfly and caddisfly taxa were more abundant at 0-208 than at any other mainstem Osage River site. The invertebrate community structure shown in Figure 6 reflects this shift from the previous sites. Mayflies comprised 33% of the samples collected during the survey followed by flies,

caddisflies, and other miscellaneous groups. Major taxa collected were:

Mayflies (33%)		Flies (26%)		Caddisflies (20%)	
Tricorythodes sp.	73%	Chironomidae	97%	*Cheumatopsyche* sp.	71%
Stenonema pulchellum	15%	Simuliidae	2%	*Potamyia flava*	18%
Isonychia sp.	4%	*Bezzia/ Probezzia*, ...,	1%	*Agapetus* sp.	4%

Other (14%)	
Oligochaeta	48%
Sphaeriidae	21%
Ferrissia sp.	9%

The invertebrate community at this site was similar to the communities at 22 other sites in the Osage River Basin, primarily from the Pomme de Terre and Sac rivers of the Ozark Highland Province. Although the riffle community at 0-208 was included in the same broad cluster as previously discussed sites (Appendix Table A-24), coefficients of similarity were low. This showed the lack of similarity between their invertebrate communities. The only mainstem site which supported a similar invertebrate community to that at 0-208 was the riffle habitat at 0-33.

Water quality at 0-183, located upstream from Warsaw, Missouri and Lake of the Ozarks (Fig. 3-5, Table 2) was considered moderately polluted because sample and annual benthic invertebrate community characteristics (Fig. 7, Appendix Table A-7) were low and remained so throughout the study. This site was sampled with artificial substrate samplers. The substrate consisted primarily of silt with very little organic debris, similar to that found at 0-238. Lagoon effluents discharging into upstream tributaries were considered to have negligible effects on the water quality at

0-183 (Table 1). The silty habitat, which can partially be attributed to non-point pollution such as soil erosion, was felt to be the primary reason for the lower characteristics. Midge larva, mayflies, and aquatic earthworms were the dominant invertebrate groups collected at this site. This assemblege is almost identical to that found at sites 0-238 and 0-271 (Fig. 6). The only difference between the sites is that invertebrate density at 0-183 was lower. The dominant invertebrates collected:

Flies (58%)		Mayflies (19%)		Other (15%)	
Chironomidae	99%	Stenacron interpunctatum	67%	Oligochaeta	49%
Bezzia/ Probezzia, ...,	1%	Hexagenia limbata	19%	Argia apicalis/ tibialis	17%
		Stenonema pulchellum	8%	Sphaeriidae	12%

The invertebrate community at 0-183 was similar to those at 10 other sites in the Osage River Basin, most being located in the Western Plains Province (Appendix Table A-23, Fig. 0). The invertebrate community at 0-183 was grouped with those at 0-238 and 0-271 using cluster analysis (Appendix Table A-24). This indicates that aquatic habitat in the upper 100 miles of the mainstem Osage River was basically quite homogeneous.

Harry S. Truman Reservoir completely inundated these four sites in 1978, and the lotic conditions which existed in 1975-76 are now lentic in nature.

Bottom substrate at site 0-78 consisted primarily of sand and gravel sized fragments of limestone. This site was located on the mainstem Osage River about 4 miles downstream Bagnell Dam (Fig. 3, Table 2). During hydropower generation through the dam by Union Electric Company, water levels at this site can vary vertically as much as 10 feet or more depending on

the amount of power being generated (U.S. Army Corps of Engineers 1979b). Likewise, the low intake levels of the turbines cause colder and, at times, oxygen devoid water to be discharged. Since 1975, two fish kills have been attributed to oxygen deficient discharges from Bagnell Dam (Ryck 1976b, Czarnezki 1978). In addition to these kills, violations of Missouri's Water Quality Standards for dissolved oxygen (5.0 milligrams per liter) have been documented in this discharge (Robinson-Wilson 1977). Benthic invertebrate community characteristics at 0-78 were the lowest for samples collected from the eight mainstem sites on the Osage River (Fig. 7 & 8, Appendix Table A-7). Seasonal and annual values fell within the polluted range for statewide criteria (Table 3). The water quality in the Osage River below Bagnell Dam was, therefore, classified as polluted. This classification was primarily due to the poor quality water discharged through Bagnell Dam. Sewage lagoon effluents and the effects of two gravel dredging operations upstream from 0-78 may also contribute to the impact on the water quality in this reach (Table 1).

The vast majority of invertebrates collected at 0-78 were aquatic earthworms and isopods. No pollution sensitive stoneflies were collected. The dominant groups were:

Other (91%)		Flies (8%)		Mayflies (<1%)	
Oligochaeta	54%	Chironomidae	99%	_Caenis_ sp.	63%
Lirceus sp.	29%	_Bezzia/ Probezzia_, ...,	<1%	_Tricorythodes_ sp.	25%
Planariidae	8%			_Stenonema pulchellum_	12%

The invertebrate community structure at 0-78 is graphically depicted in Figure 9. According to coefficients of similarity, the community type

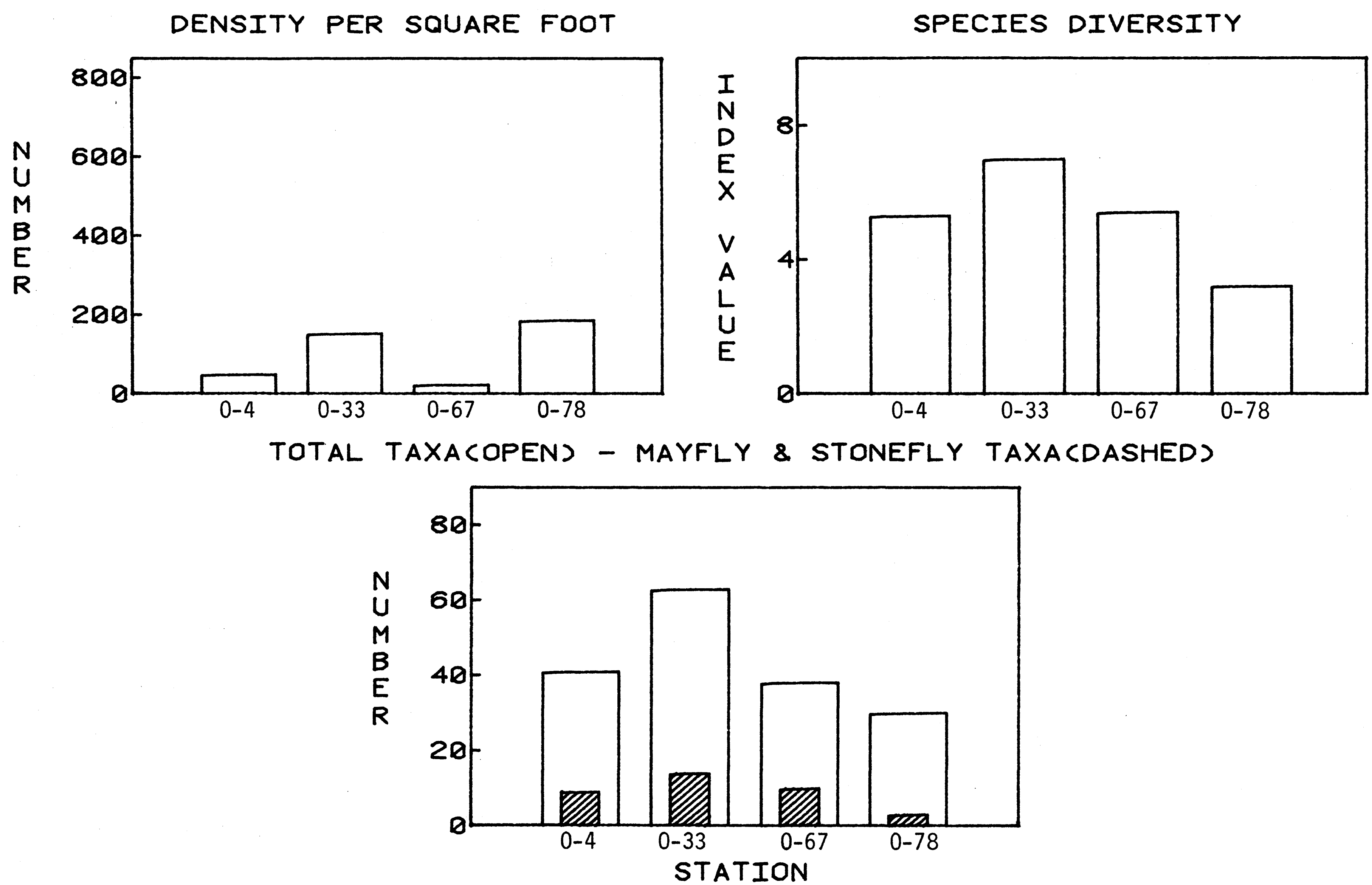


FIGURE 8. BENTHIC INVERTEBRATE COMMUNITY CHARACTERISTICS FOR SAMPLES FROM THE MAINSTEM OSAGE RIVER BELOW BAGNELL DAM- 1975-76.

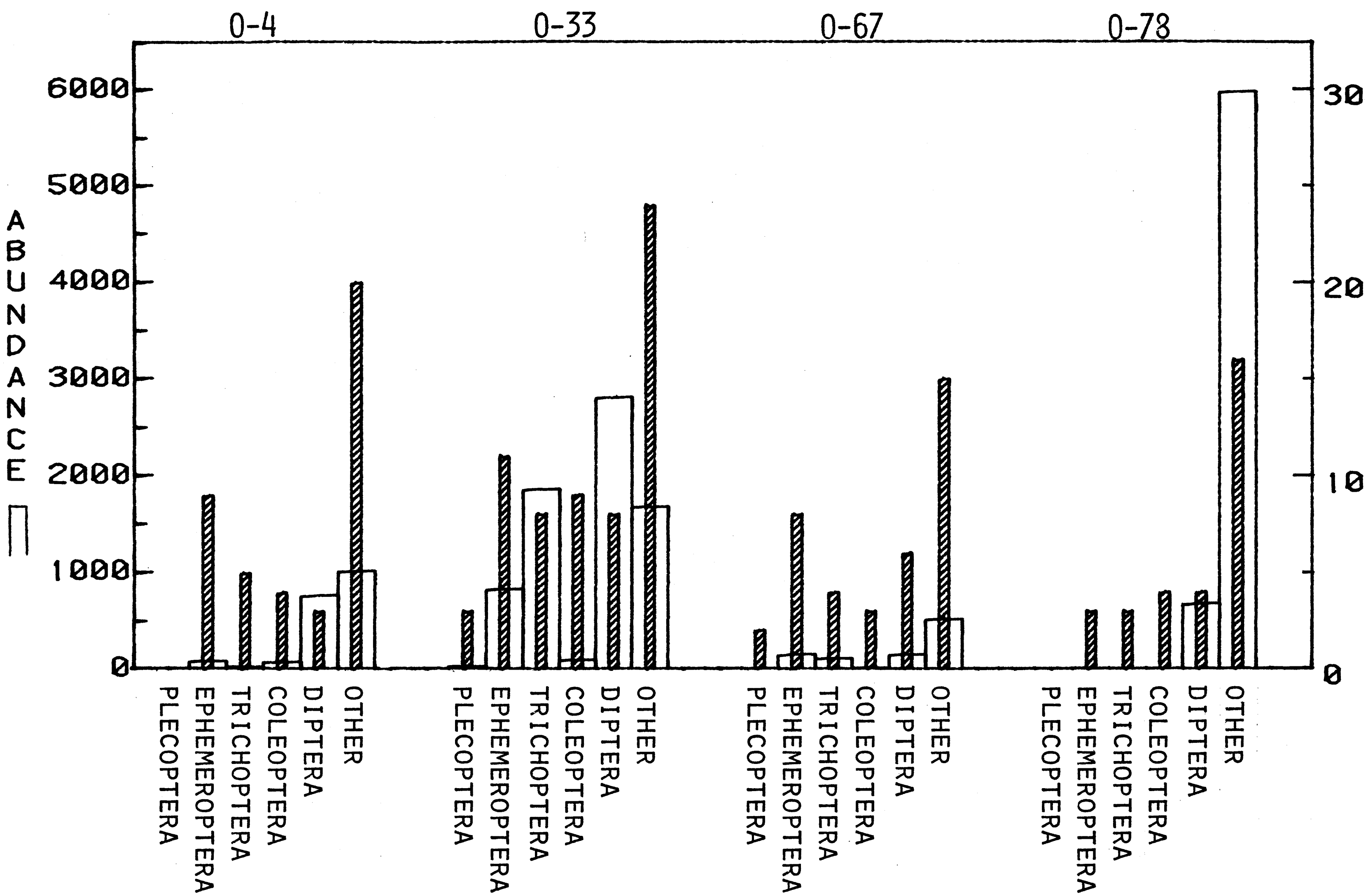


FIGURE 9. COMMUNITY STRUCTURE OF BENTHIC INVERTEBRATES BY ABUNDANCE AND TAXA FOR SAMPLES FROM THE MAINSTEM OSAGE RIVER BELOW BAGNELL DAM- 1975-76.

at 0-78 was similar to that at only one other site in the entire Osage River Basin. That site was located on a 6th order stream, Big Creek (Ogb-5), in Henry County (Fig. 5). Cluster analysis did not pair the invertebrate community at 0-78 with any other site in the Osage River Basin.

Water quality conditions were not as severe 11 miles downstream at 0-67 (Fig. 3, Table 2). Although invertebrate density was quite low (22 organisms per square foot) when compared to the other sites on the mainstem Osage River (Fig. 7 & 8), the benthic invertebrate community characteristics (Appendix Table A-7) generally fell in the moderately polluted range (Table 3). Seven small lagoon discharges were identified between 0-67 and 0-78 during the survey (Table 1). Three discharged directly to the mainstem and the other four discharged into tributary streams. These discharges may have contributed but the primary cause of the degraded water quality at this site was felt to be a continuation of the stressed conditions found at 0-78. Stream substrate at this site was considered adequate for good invertebrate production, however, a diverse invertebrate community was found only during the winter months when hydropower generation was minimal (Appendix Table A-7). During that season, fair populations of pollution sensitive stoneflies, mayflies, and caddisflies were collected. These populations were reduced or absent during the remaining seasons. Dominant invertebrate groups in the samples collected at 0-67 were:

Other (54%)		Mayflies (16%)		Flies (15%)	
Corbicula leana	25%	*Stenonema pulchellum*	69%	Chironomidae	95%
Hyalella azteca	20%	*Tricorythodes* sp.	14%	*Chaoborus* sp.	2%
Lirceus sp.	19%	*Leptophlebia* sp.	5%		
Oligochaeta	9%				
		Caddisflies (12%)			
		Cheumatopsyche sp.	82%		
		Agraylea sp.	16%		
		Hydropsyche cuanis	1%		
		Hesperophylax sp.	1%		

The invertebrate community structure (Fig. 9) and habitat at 0-67 was unique to that reach of the Osage River. The community was not similar to, and did not cluster with, any other community in the entire Osage River Basin.

The effects of oxygen deficient discharges from Bagnell Dam and seven treated sewage effluents, including municipal sewage effluent from Eldon, Missouri, were not detected at 0-33 (Fig. 3, Table 2). The habitat at this site, which consisted of riffle and pool habitat similar to that at 0-208, supported the most diverse community of pollution sensitive invertebrates of the eight mainstem Osage River sampling sites. Benthic invertebrate community characteristics consistently exceeded the criteria for unpolluted Missouri streams (Table 3) with an exception in the number of mayfly and stonefly taxa (Appendix Table A-7). Water quality was classified unpolluted because of these high characteristic values and the presence of numerous pollution sensitive taxa in addition to mayflies and stoneflies (Fig. 9). Dominant invertebrate groups in the samples collected at 0-33 were:

Flies (39%)		Caddisflies (25%)		Other (23%)	
Chironomidae	98%	*Cheumatopsyche* sp.	72%	*Goniobasis* sp.	64%
Empididae	1%	*Potamyia flava*	21%	Oligochaeta	10%
Muscidae	<1%	*Hydroptila* sp.	5%	*Lirceus* sp.	5%
		Mayflies (11%)			
		Tricorythodes sp.	65%		
		Stenonema pulchellum	23%		
		Caenis sp.	6%		

The community structure of the invertebrates at 0-33 was similar to 22 other sites distributed throughout the Osage River Basin (Appendix Table A-23).

The community at 0-33 clustered with other larger streams in the Cherokee Plains, Osage-Gasconade Hills, and Springfield Plain such as 0-271, 0-238, 0-208, 0-183, and Omdc-9, Op-27, and Oma-11. In addition to these, however, some smaller order 4 and 5 streams were also included in this cluster (Ogv-12, Ogv-17, Ost-6, Obb-5, Ot-5, and others). All sites in this cluster primarily had midges (Family Chironomidae), mayflies (*Tricorythodes* sp.) and caddisflies (*Cheumatopsyche* sp.) as dominant invertebrate groups (Appendix Table A-24).

The invertebrate community in the Osage River near its mouth at 0-4 (Fig. 3, Table 2) was quite similar (C=70) to that found in the mainstem of Tebo Creek at Ogt-18 (Fig. 5). These two sites were also placed in the same cluster which contained three other sites (Omlw-9, Os-49, and Ogts-2). All sites are characterized by low density communities of midges (Family Chironomidae), aquatic earthworms (Oligochaetes), Sphaeriid clams, and mayflies such as: *Stenacron interpunctatum*. The primary reason for low density communities at these sites was a lack of suitable habitat for invertebrate production created by an unstable sand and/or silt substrate. In the Osage River near its mouth, an unstable sand bottom overlain by silt in many areas was at least partly responsible for the low invertebrate production. Upstream non-point erosion from natural and man-made causes and its resulting sedimentation was considered a contributing factor at 0-4. The benthic invertebrate community characteristics (Appendix Table A-7) fell within the moderately affected range throughout the survey (Table 3). The benthic invertebrate community at 0-4 consisted of the following groups:

Other (52%)		Flies (39%)		Mayflies (4%)	
Oligochaeta	58%	Chironomidae	98%	Hexagenia limbata	55%
Corbicula leana	18%	Bezzia/ Probezzia, ...,	2%	Tricorythodes sp.	24%
Argia apicalis/ tibialis	7%			Stenacron interpunctatum	11%
Sphaeriidae	4%				

Although point source pollution discharged into the Osage River at various locations upstream from 0-4 (Table 1), the large volume of flow in comparison to the discharges which enter this 8th order stream, made any effects undetectable.

In summary, the mainstem Osage River is an order 8 stream for its entire 280 mile length. Of the eight sampling sites established along this river, the two sites located within the 15 mile reach below Bagnell Dam (0-78 and 0-67) showed obvious water quality degradation from pollution. Samples from this reach exhibited reduced invertebrate community characteristics and dissimilar communities from the other mainstem sites and normal unaffected Missouri streams. The primary cause of the poor water quality in this reach was considered to be the periodic oxygen deficient discharges through Bagnell Dam. Other point source discharges of pollution, primarily poorly treated sewage effluent, entered tributaries of the Osage River throughout its length (Table 1). Impacts, if any, from these sources were localized and not detected at the sample sites. The large flow in the Osage River in comparison to the point source discharges minimized any extensive downstream effects.

Four of the six remaining sites (0-271, 0-238, 0-183, & 0-4) showed moderately polluted water quality. These conditions were primarily considered

a function of habitat (silt, organic debris, sand substrate, or a combination). Non-point erosion and resulting sedimentation was considered in part responsible for the less productive substrate at these sites. The remaining sites (0-208 & 0-33) were classified unpolluted, based on benthic invertebrate community characteristics which approached or exceeded statewide criteria for unpolluted streams. The invertebrate communities at these two sites were well represented by pollution sensitive taxa.

The eight mainstem sites were grouped into four clusters based on community structure using cluster analyses. These clusters were a reflection of different water quality and/or habitat conditions. The four upstream sites (0-271, 0-238, 0-208, and 0-183) and 0-33 belonged to a cluster characterized by midge larvae (Family Chironomidae), mayflies (*Tricorythodes* sp.), and caddisflies (*Cheumatopsyche* sp.). Water quality in these upper reaches were classified as either polluted or moderately polluted. As mentioned previously, reaches of the Osage River monitored at sites 0-78 and 0-67 were classified polluted and moderately polluted, respectively. These conditions resulted from discharges through Bagnell Dam. Neither site clustered with any other in the Osage River Basin. The invertebrate community near the mouth of the Osage River (0-4) was grouped with those at four other sites in the basin characterized by a low density community of midge larvae (Family Chironomidae), aquatic earthworm (Class Oligochaeta), fingernail clams (Family Sphaeriidae), and mayflies (*Stenacron interpunctatum*). The aquatic environment at these sites was considered unstable because of either variable flows caused by hydropower generation or an abundance of sand in the substrate.

The two most influential forces identified in the mainstem Osage River during this survey were the construction of Truman Reservoir and Lake of

the Ozarks and oxygen deficient discharges through Bagnell Dam. Reservoir construction eliminated 200 miles of the Osage River, and the discharges through Bagnell Dam affected another 13 miles. Together, 76% of the original mainstem Osage River have been severely altered by these man induced changes.

Minor Mainstem Tributaries of the Osage River

The tributaries discussed in this subsection are order 4 and 5 streams which discharge directly into the Osage River. The only exception to this is Clear Creek in St. Clair County (Oc-10; Fig. 4) which is an order 6 stream. Likewise, all minor mainstem tributaries flow through the Ozark Highland Province shown in Figure 0 except Clear Creek which is in the Cherokee Plains Region of the Western Plains Province. Collectively, these tributaries support one of the most diverse assembleges of benthic invertebrates (172 taxa) in the eight Osage River Basin subdivisions. This number was equaled only by the Sac River Basin. These minor mainstem tributaries also exceeded all other subdivisions of the Osage River Basin in the number of pollution sensitive mayfly and stonefly taxa (47 taxa). A total of 89 species of fish are collectively found in these tributaries by Pflieger (1975). This was second to the mainstem Osage River in diversity of fish fauna (Table 4). The major mainstem tributaries (order 6 and 7) are discussed separately in later sections.

Maries River

The Maries River originates at Dixon, Missouri in Pulaski County and flows north through Maries and Osage counties before entering the Osage River about 6 miles from its confluence with the Missouri River (Fig. 3). Its course is wholely contained within the Ozark Highland Province and

flows across the Osage-Gasconade Hills and Northern Ozark Border regions (Fig. 0). Maries River is normally clear, containing well oxygenated water which flows over a streambed consisting of varying sized and shaped fragments of chert and dolomitic limestone. The overall habitat in this stream is very productive and supports a wide variety of aquatic plants, invertebrates, and vertebrates. According to Pflieger (1978), 17 miles of Maries River (between river mile 13-29) and 1 mile of Little Maries River (at its mouth) support populations of Niangua darters, Etheostoma nianguae. This darter has been classified as rare in Missouri (Nordstrom, Pflieger, Sadler and Lewis 1977) and recommended for inclusion on the U.S. Department of the Interior's list, Threatened Wildlife of the United States (Pflieger 1978). The Maries River is one of eight basins which support the remaining populations of Niangua darters. All eight basins are contained within the Osage River System. Vineyard and Feder (1974) do not list any springs within the Maries River Drainage which suggests that much of its flow comes from surface runoff. The Maries River at Westphalia, Missouri, 10 miles above its mouth, drains 257 square miles and had an average discharge of 211 cubic feet per second over a 22 year period (U.S. Geological Survey 1970).

The headwater sampling site on Maries River (Oma-46 was located on a 2nd order segment approximately 1.5 miles downstream from the sewage treatment lagoon (10.7 acres) serving Dixon, Missouri (Fig. 3, Tables 1 & 2). This lagoon was the only point source of pollution identified upstream from the sample site during this survey. The excessive nutrients from this discharge resulted in denser than normal periphyton growths in this stream reach during most of the year. Benthic invertebrate community characteristics for the samples collected at Oma-46 were consistently within the

moderately polluted range (Fig. 10, Appendix Table A-9). Water quality in this reach was classified as moderately polluted. The benthic invertebrate community structure consisted primarily of pollution tolerant and facultative forms. Some sensitive taxa like stoneflies, however, were collected in low densities during the winter and spring of 1976 (Fig. 11). The dominant taxonomic groups at Oma-46 were:

Flies (76%)		Other (10%)		Caddisflies (6%)	
Chironomidae	71%	Oligochaeta	78%	_Cheumatopsyche_ sp.	69%
Simuliidae	28%	Planariidae	8%	_Hydropsyche betteni_	14%
Empididae	1%	_Asellus_ sp.	5%	_H. cuanis_	8%

The invertebrate community at Oma-46 was similar to the communities at 19 other sites located throughout the Osage River Basin (Appendix Table A-23). Of these similar sites, 37% were located on 4th order streams within the Ozark Highland Province (Fig. 0). The remainder were from higher order streams distributed throughout the Osage River Basin. The invertebrate community at Oma-46 was almost identical (C=82) to that inhabiting the East Fork of Tebo Creek (Ogte-5) in Henry County (Fig. 5). The East Fork also receives treated sewage effluent from three large lagoons serving Windsor, Missouri. The invertebrate community at Oma-46 was grouped with 11 other sites within the Osage River Basin. These communities were all characterized by medium to high density communities of tolerant invertebrates such as midge and biting midge larvae (Family Chironomidae and _Bezzia/ Probezzia_, ...,), aquatic earthworms (Class Oligochaeta) and mayflies (_Stenacron interpunctatum_). The community at Oma-46 was most closely aligned with the communities at Ogte-5, Occ-11, and Oss-11 (Figs. 3-5).

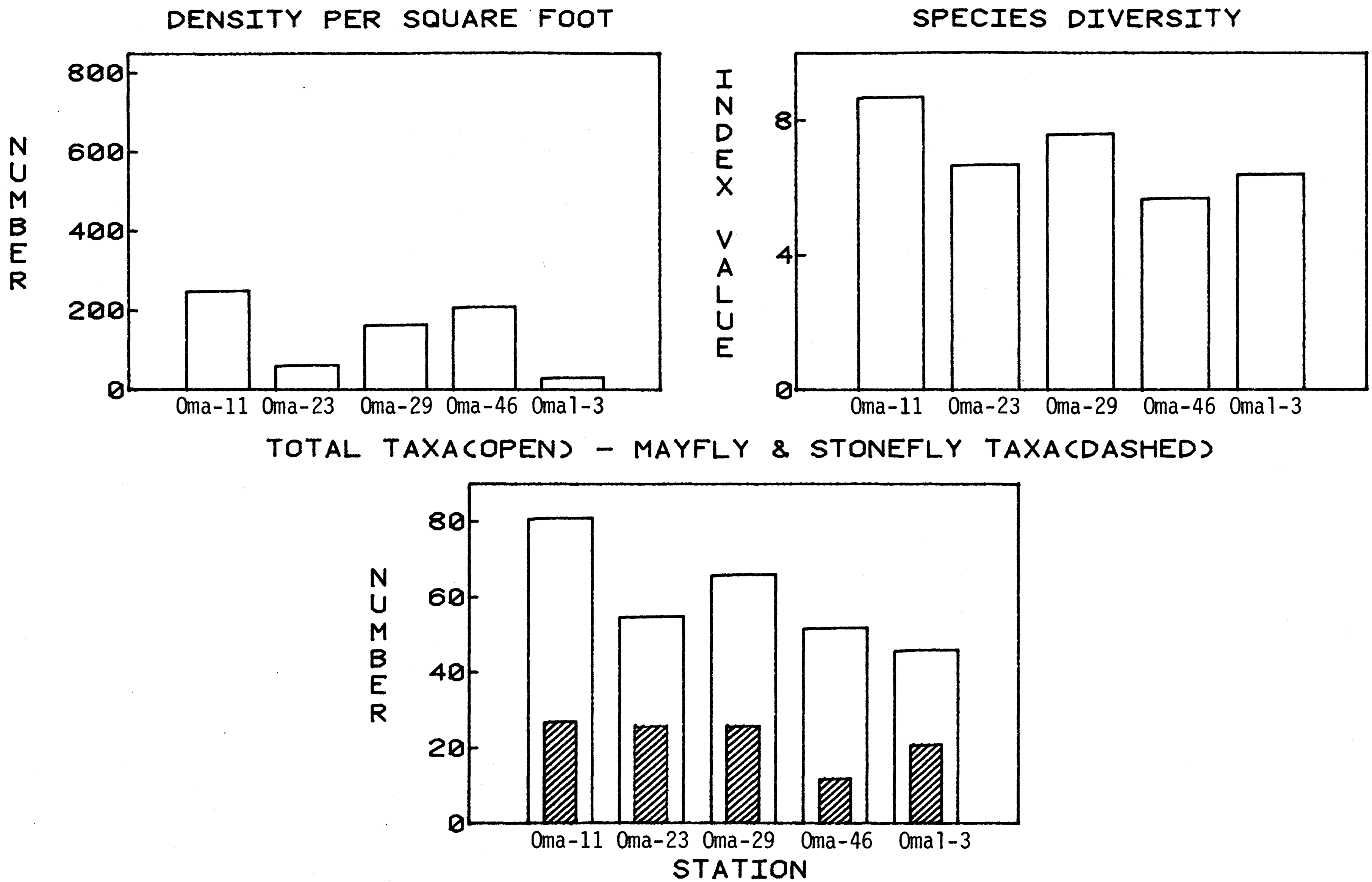


FIGURE 10. BENTHIC INVERTEBRATE COMMUNITY CHARACTERISTICS FOR SAMPLES FROM THE MARIES AND LITTLE MARIES RIVERS- 1975-76.

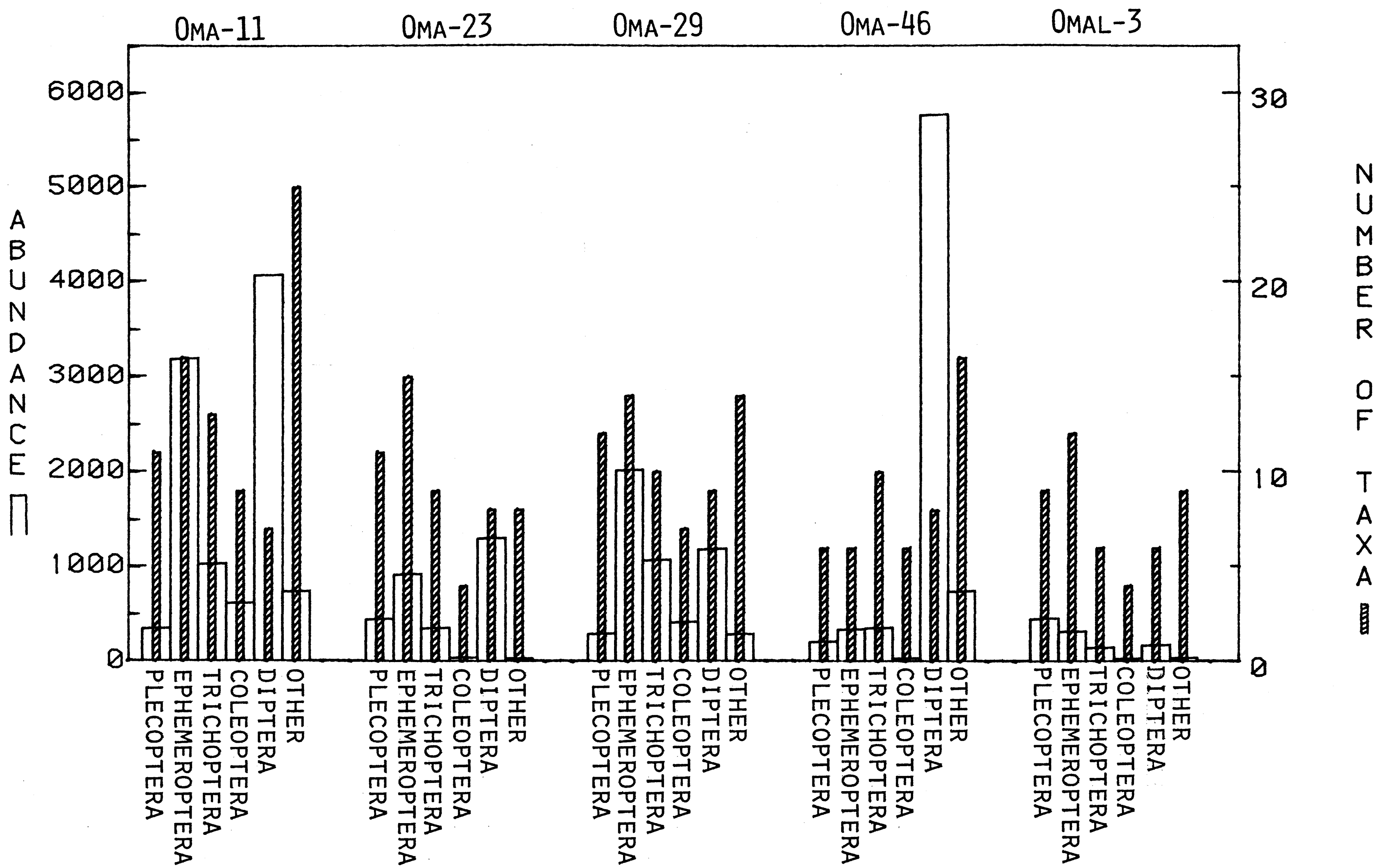


FIGURE 11. COMMUNITY STRUCTURE OF BENTHIC INVERTEBRATES BY ABUNDANCE AND TAXA FOR SAMPLES FROM THE MARIES AND LITTLE MARIES RIVERS- 1975-76.

During the summer of 1977, a fish kill was documented in Maries River upstream from Oma-46. An undetermined number of fish were killed from low oxygen concentrations in the stream below the Dixon lagoon. This incident aroused citizen concern, prompting a request for additional information in early 1978. Benthos samples were collected from Maries River above (Oma-46A) and below (Oma-46B) the Dixon lagoon and at Oma-46 on March 14, 1978 and at Oma-46B and Oma-46 on August 4, 1978. Maries River at Oma-46A was dry during the August 1978 sampling. Benthic invertebrate community characteristics and coefficient of similarity values for the 1978 samples and comparative 1975-76 samples are summarized in Table 6.

Table 6. Benthic invertebrate community characteristics and coefficient of similarity values for samples collected from Maries River during 1978 and comparative data collected during the 1975-76 survey.

Site	Date	Sample Density	Mayfly and Stonefly Taxa	Total Taxa	Diversity Index (d)	Coefficient of Similarity
Oma-46A	3/14/78	14	3	11	2.1	
						--- 16
Oma-46B	3/14/78	48	2	7	1.0	
						--- 56
Oma-46	3/14/78	69	3	16	2.4	
						--- 24
Oma-46	3/30/76	360	8	28	3.4	
Oma-46A	8/4/78	Stream	Dry; No Sample	Collected		
Oma-46B	8/4/78	70	1	9	1.3	
						--- 42
Oma-46	8/4/78	290	8	25	3.1	
						--- 79
Oma-46	9/30/75	92	5	21	3.0	

In 1978, the benthic invertebrate community in Maries River at Oma-46 continued to be degraded by the discharge from the lagoon serving Dixon,

Missouri. Heavy growths of sewage fungus (Sphaerotilus sp.) in Maries River immediately below the lagoon (Oma-46B); the presence of pollution tolerant taxa at Oma-46, benthic invertebrate community characteristics in the polluted range at Oma-46B and the moderately polluted range further downstream at Oma-46, heavy growths of filamentous algae at Oma-46 during 1975, 1976, and 1978; and the absences of such growths in the intermittent reach above the lagoon (Oma-46A) all demonstrate the adverse effects of this discharge. These impacts are caused by the grossly overloaded condition of this lagoon. Maries River will continue to be classified moderately polluted in this reach as long as the facility remains overloaded. Plans to upgrade this facility were scheduled to begin in 1981 (Personal communication, 1980, Ronald Testerman, Wastewater Works Specialist, Missouri Department of Natural Resources, Division of Environmental Quality, Jefferson City Regional Office, Jefferson City, Missouri). The new facility was completed in early 1983 and is presently in operation.

Water quality conditions 17 miles downstream at Oma-29 had improved markedly from those at Oma-46 (Fig. 3, Table 2). The effects from the Dixon lagoon were no longer evident and other pollutant sources were not identified upstream from this site. Benthic invertebrate community characteristics (Fig. 10, Appendix Table A-9) exceeded statewide criteria (Table 3) throughout the survey. Pollution sensitive taxa were well represented in the samples collected from Oma-29 (Fig. 11). The Maries River had recovered from upstream water quality problems and this reach was classified unpolluted. The benthic invertebrate community at Oma-29 was similar in structure to 18 other sites in the Osage River Basin, with 83% of these sites located within the Ozark Highland Province. The community at Oma-29 clustered with the large group of sites characterized by populations of midges (Family Chironomidae), mayflies

(*Tricorythodes* sp.), and caddisflies (*Cheumatopsyche* sp.). Included in this cluster were mostly Ozark streams and five mainstem Osage River sites: O-33; O-183; O-208; O-238; and O-271. The invertebrate community at Oma-29 was most closely aligned with that found at O-208. Dominant taxa in this reach of the Maries River were:

Mayflies (38%)		Flies (22%)		Caddisflies (20%)	
Tricorythodes sp.	56%	Chironomidae	95%	*Cheumatopsyche* sp.	76%
Ephemerella dorothea/excrucians	13%	Simuliidae	1%	*Agraylea* sp.	9%
Stenonema pulchellum	11%	Empididae	1%	*Chimarra obscura*	4%
		Beetles (8%)			
		Psephenus herricki	76%		
		Stenelmis sp.	16%		
		Ectopria nervosa	4%		

Treated sewage effluent from a 4-cell lagoon serving Vienna, Missouri (Table 1) is discharged into Maries River, via Fly Creek, 4 miles upstream from Oma-23 (Fig. 3, Table 2). During the survey, most benthic invertebrate community characteristics approached statewide criteria for unpolluted streams (Table 3) and the number of pollution sensitive mayfly and stonefly taxa exceeded these standards (Appendix Table A-9). The large variety of pollution sensitive taxa (Fig. 11) and low numbers of tolerant forms indicate little, if any, influence from this lagoon effluent on the water quality in Maries River at Oma-23. For this reason, water quality at Oma-23 was classified unpolluted. The slight depression of annual total taxa, and seasonal and annual species diversity values was attributed to very low

sample densities during the fall and winter seasons and large quantities of fine sand and gravel sized limestone fragments in the substrate. The invertebrate community at Oma-23 clustered with 4 other Ozark Highland Province streams which also supported low density communities of sensitive invertebrates. All sites had a less stable substrate than typical Ozark streams resulting from a larger proportion of fine particles in the substrate. The communities within this cluster were typified by a predominance of midges, mayflies and stoneflies. The community at Oma-23 was most closely aligned with that at Oln-132, near the headwaters of the Little Niangua River (Fig. 3). In addition to the four sites in this cluster, the invertebrate community at Oma-23 was similar to those at nine other sites on order 4 and 5 Ozark streams in the Osage River Basin (Appendix Table A-23). The invertebrate community in Maries River at Oma-23 was characterized as follows:

Flies (42%)		Mayflies (29%)		Stoneflies (14%)	
Chironomidae	87%	*Rhithrogena* sp.	23%	*Neoperla* sp.	33%
Empididae	5%	*Tricorythodes* sp.	16%	*Isoperla* sp.	33%
Chrysops sp.	1%	*Stenonema pulchellum*	11%	*Allocapnia* sp.	14%
		Pseudocloeon sp.	9%	*Perlesta placida*	6%
		Caddisflies (11%)			
		Cheumatopsyche sp.	81%		
		Agraylea sp.	6%		
		Chimarra obscura	6%		
		C. aterrima	2%		

Little Maries River, its major tributary, enters Maries River from the west a short distance downstream from Oma-23. The sampling site on Little

Maries River (Oma1-3) was located at Maries County Route T crossing, 3 miles above its mouth (Fig. 3, Table 2). No pollution sources were identified in the watershed of Little Maries River during the survey. Habitat conditions at this site resembled those at Oma-23 in that the substrate consisted of greater quantities of sand and gravel sized fragments of chert and limestone than typical Ozark streams. The low density benthos community in Little Maries River at Oma1-3 averaged 31 organisms per square foot (Fig. 10, Appendix Table A-9). A large proportion of the taxa at this site were represented by pollution sensitive mayflies, stoneflies, and caddisflies (Fig. 11). As before, the number of mayfly and stonefly taxa and several seasonal diversity index values exceeded the criteria for unpolluted streams. Annual values for total taxa and species diversity only approached these criteria (Appendix Table A-9). Water quality in Little Maries River was judged unpolluted based on the pollution sensitive community which inhabited the stream. Low invertebrate densities were attributed to a moderately stable substrate and not stress caused by pollution. Dominant taxa in the samples collected from Oma1-3 were:

Stoneflies (39%)		Mayflies (27%)		Flies (15%)		Caddisflies (12%)	
Allocapnia sp.	52%	*Stenonema femoratum*	22%	Chironomidae	88%	*Cheumatopsyche* sp.	90%
Isoperla spp.	26%	*Rhithrogena* sp.	15%	Simuliidae	6%	*Helicopsyche* sp.	3%
Neoperla sp.	12%	*Ephemerella dorothea/excrucians*	13%	*Chrysops* sp.	3%	*Chimarra obscura*	1%
Strophopteryx sp.	4%						

Coefficient of similarity values for Oma1-3 showed similar invertebrate communities at only two other sites on Ozark Highland Province streams,

Otv-6 and Oln-132 (Fig. 3). The similarities, however, were not very strong (C=50 for both). The community in Little Maries River was only aligned with the community in Tavern Creek at Otv-6 by cluster analysis. Communities at these two sites were characterized by a mayfly-stonefly-midge association. This is opposite to the midge-mayfly-stonefly cluster discussed for Maries River at Oma-23.

Four small discharges to tributaries and an undiked oil storage site were identified upstream from the lower sampling site (Oma-11) on Maries River (Table 1). The benthos community at this site showed no adverse effects from these pollution sources. Benthic invertebrate community characteristics were considered high (Fig. 10, Appendix Table A-9) and consistently exceeded the criteria for unpolluted Missouri streams (Table 3). Invertebrate density was also high, averaging 250 organisms per square foot. This community had the highest annual diversity (d=8.7) and the most taxa collected over the sampling year (81) of all 85 sampling sites in the Osage River Basin. Also, there were good populations of naiades (Phylum Mollusca) at Oma-11. Nine species were collected during the survey with minimal effort. These included six species from dead shell material collected on the stream-bank and three species collected alive during benthos sampling. Water quality in this section of Maries River was classified as unpolluted based on the benthos community. The distribution of taxa at Oma-11 was similar to that at Oma-29, upstream from Vienna, Missouri (Fig. 11). Cluster analysis grouped the benthos community at Oma-11 with Oma-29 and 17 other sites in the Osage River Basin (Appendix Table A-24). Communities in this cluster were characterized by midges, Tricorythid mayflies, and Cheumatopsychid caddis-flies. Dominant taxa at Oma-11 consisted of:

Flies (40%)		Mayflies (32%)		Caddisflies (10%)	
Chironomidae	80%	*Tricorythodes* sp.	59%	*Cheumatopsyche* sp.	61%
Simuliidae	18%	*Stenonema pulchellum*	12%	*Chimarra obscura*	23%
Empididae	<1%	*S. mediopunctatum*	6%	*Hydroptila* sp.	12%
		Isonychia sp.	6%		

Water quality throughout the Maries River was quite good with the exception of the headwater reach which was degraded by discharges from an overloaded lagoon at Dixon, Missouri. Complete recovery from this problem occurred within 17 miles downstream from the discharge. Pollution sources identified throughout the Maries River Basin were primarily discharges of treated sewage effluent. With the exception of the problems in the headwaters, these sources had minimal effect on the water quality in Maries River. With a few exceptions, benthic invertebrate communities at sites throughout Maries River were similar to other communities inhabiting streams in the Ozark Highland Province. In sharp contrast to the degradation found in the headwaters of Maries River (Oma-46) was the community of invertebrates living near the mouth (Oma-11). This community was the most diverse community of any sampled in the Osage River Basin. Future water quality conditions in Maries River are dependent on the abatement of the headwater problems and future growth throughout the watershed. Proper planning and pollution abatement are imperative to maintain the present unpolluted status of Maries River and to insure the survival of the Niangua darter in the reaches between Oma-29 and Oma-11 on Maries River and downstream from Omal-3 on Little Maries River.

Tavern Creek

Tavern Creek was sampled at two sites during the 1975-76 survey. The upper site (Otv-30), 30 miles above mouth, was located near the Highway 42 crossing, east of Iberia, Missouri (Fig. 3, Table 2). The lower site (Otv-6) was near St. Elizabeth, Missouri, 6 miles from the confluence of Tavern Creek with the Osage River (Fig. 3, Table 2). Tavern Creek flows a total of 53 miles, and its basin is wholly contained within the Osage-Gasconade Hills Region of the Ozark Highland Province (Fig. 0).

Tavern Creek is a typical Ozark stream. It is normally clear and has oxygen levels at or near saturation. The stream habitat is a succession of short pools and well defined riffles in headwater areas with pool length increasing downstream. Substrate consisted of varied sized fragments of chert and limestone with a composition similar to that found at Oma-23 and Omal-3. According to Pflieger (1978), the lower 30 miles of Tavern Creek are considered prime habitat for Niangua darters and support one of the eight known populations of this fish species. No sources of pollution were identified in the basin during the survey (Table 1). The benthic invertebrate communities at both sites consisted of numerous pollution sensitive taxa (Fig. 12). Community characteristic values (Fig. 13, Appendix Table A-9) consistently exceeded statewide criteria for unpolluted streams (Table 3). Water quality at Otv-6 and Otv-30 was classified unpolluted based on these data. Although the basic invertebrate community structure at these two sites was considered similar (C=56), they did not align in the same clusters based on dominant taxonomic groups. The community at Otv-6 was placed in a cluster containing one other sampling site, Omal-3 on Little Maries River. The dominant taxa at Otv-6 consisted of:

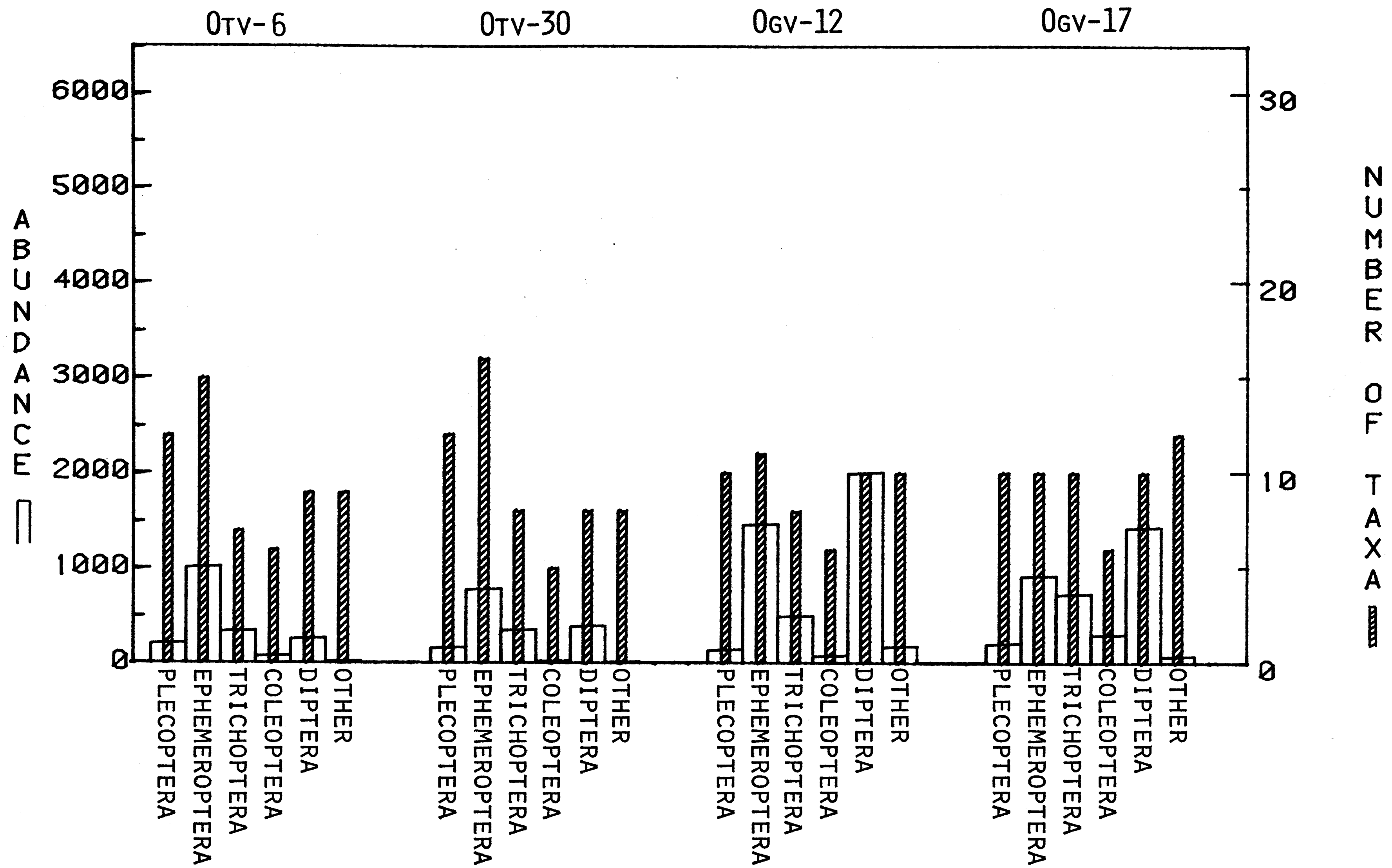


FIGURE 12. COMMUNITY STRUCTURE OF BENTHIC INVERTEBRATES BY ABUNDANCE AND TAXA FOR SAMPLES FROM TAVERN AND GRAVOIS CREEKS- 1975-76.

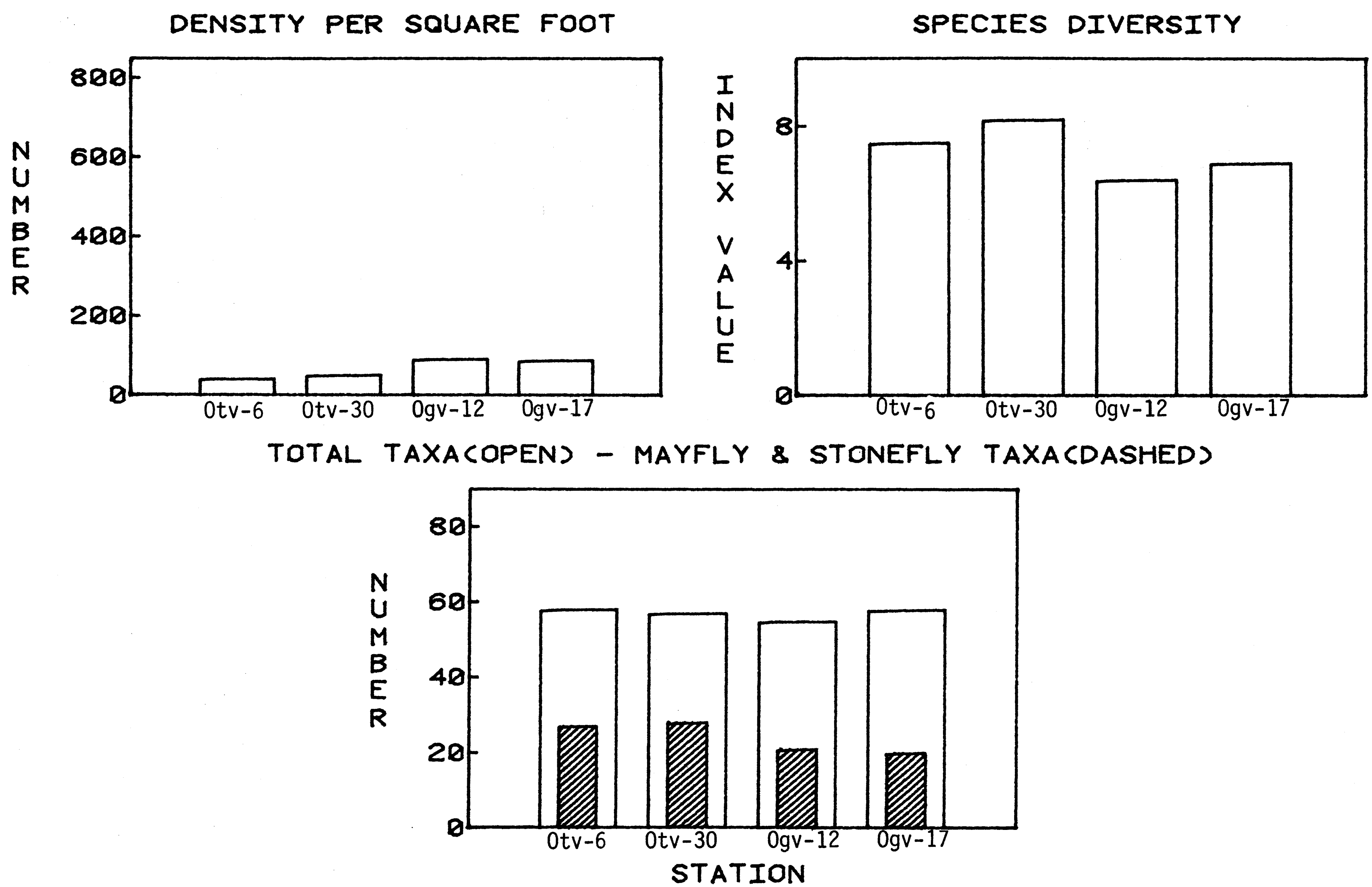


FIGURE 13. BENTHIC INVERTEBRATE COMMUNITY CHARACTERISTICS FOR SAMPLES FROM TAVERN AND GRAVOIS CREEKS- 1975-76.

Mayflies (52%)		Caddisflies (18%)		Flies (14%)	
Hexagenia limbata	46%	*Cheumatopsyche* sp.	89%	Chironomidae	45%
Rhithrogena sp.	20%	*Symphytopsyche bifida*	5%	Simuliidae	45%
Tricorythodes sp.	10%	*Chimarra obscura*	4%	Empididae	3%
		Stoneflies (11%)			
		Neoperla sp.	41%		
		Allocapnia sp.	19%		
		Strophopteryx sp.	18%		
		Isoperla mohri	8%		

The invertebrate community at Otv-30 was similar to those at six other sites in the Ozark Highland Province (Appendix Table A-23). This community was included in a cluster containing five of these six similar sites (Appendix Table A-24). The community at this upstream site on Tavern Creek was characterized by:

Mayflies (45%)		Flies (22%)		Caddisflies (20%)	
Stenonema mediopunctatum	18%	Chironomidae	90%	*Cheumatopsyche* sp.	78%
Rhithrogena sp.	16%	Simuliidae	6%	*Chimarra obscura*	15%
Baetis sp.	15%	*Atherix lantha*	2%	*Symphitopsyche bifida*	5%
		Stoneflies (9%)			
		Allocapnia sp.	37%		
		Isoperla mohri	26%		
		Strophopteryx sp.	12%		
		I. bilineata/richardsoni	8%		

Tavern Creek can be considered a pristine Ozark stream, essentially unaffected by man's activities. The excellent water quality and population of Niangua darters which inhabits the lower 30 miles are presently not in jeopardy from degrading effects of pollution. The future in this basin looks bright providing man's influences do not intensify.

Gravois Creek

Like Tavern Creek, the watershed of Gravois Creek is wholly contained within the Osage-Gasconade Hills Region (Fig. 0). It begins just south of Stover, Missouri (Morgan County) and flows for 39 miles before joining the Osage River as an order 5 stream near Sunrise Beach. The completion of Lake of the Ozarks in 1931 permanently inundated the lower 28% (11 miles) which included all order 5 reaches of this stream. Aquatic habitat in Gravois Creek was typical of an Ozark stream. Water was very clear. Riffle substrate was more stable at both sample sites than in Tavern Creek primarily because of larger chert and limestone fragments.

Fourteen pollution sources were identified in the Gravois Creek watershed during the 1975-76 survey (Table 1). Nine of these were discharges of treated sewage effluent from various facilities including the city of Versailles, Missouri. The remaining sources were a poultry farm and four gravel dredging operations. All pollution sources except two gravel dredging operations discharged into tributaries or mainstem reaches of Gravois Creek which flow into or make up the Gravois Arm of Lake of the Ozarks. The upstream sampling site, Ogv-17, was located upstream from two of the gravel operations, 3.5 miles west of the Highway 5 crossing of Gravois Creek (Fig. 3, Table 2). Pollution sensitive taxa were well represented at this site. In fact, approximately equal numbers of taxa were found in each of the six taxonomic groups shown in Figure 12. Community characteristics for samples from this site approached and exceeded statewide criteria (Table 3,

Fig. 13, Appendix Table A-9). Water quality in the upper reaches of Gravois Creek was classified unpolluted. This benthos community was similar to those at 16 other sites in the Osage River Basin of which 88% were on streams in the Ozark Highland Province (Appendix Table A-23). Dominant taxa at Ogv-17 were:

Flies (39%)		Mayflies (25%)		Caddisflies (20%)	
Chironomidae	94%	*Tricorythodes* sp.	32%	*Cheumatopsyche* sp.	64%
Empididae	2%	*Stenonema pulchellum*	21%	*Symphitopsyche bifida*	17%
Hexatoma spp.	1%	*Heptagenia* sp.	13%	*Helicopsyche* sp.	10%
		Pseudocloeon sp.	10%		
		Ephemerella bicolor	10%		
		Beetles (8%)			
		Optioservus sandersoni	67%		
		Psephenus herricki	22%		
		Stenelmis sp.	6%		

The invertebrate communities at Ogv-17 and Ogv-12 were quite similar (C=74). Both sites were included in the cluster containing midge-mayfly-caddisfly communities. Previously discussed sites in this cluster included O-271, O-238, O-208, O-183, and O-33 on the mainstem Osage River and Oma-29 and Oma-11 on Maries River. The invertebrate community and water quality at Ogv-12 did not appear to be adversly impacted by two upstream gravel operations. Benthic invertebrate community characteristics were high (Fig. 13, Appendix Table A-9) and pollution sensitive taxa were well represented (Fig. 12). The water quality at this site was also classified

unpolluted. The community at Ogv-12 consisted of the following major groups:

Flies (46%)		Mayflies (34%)		Caddisflies (11%)	
Chironomidae	94%	Tricorythodes sp.	62%	Cheumatopsyche sp.	61%
Empididae	4%	Baetis sp.	13%	Symphitopsyche bifida	22%
Bezzia/ Probezzia, ...,	1%	Pseudocloeon sp.	9%	Helicopsyche sp.	12%

The permanent inundation of 11 miles (28%) of Gravois Creek by the completion of Bagnell Dam which formed Lake of the Ozarks, was the most destructive activity affecting this stream. The gravel operations identified during the survey on the remaining 28 mile portion had no detectable effects upon the invertebrate community and water quality downstream. The free-flowing reaches of Gravois Creek not flooded by Lake of the Ozarks were considered unpolluted based on the data collected at the two sample sites. The effects of the treated sewage effluent on the Gravois Arm of Lake of the Ozarks were not studied, however, they in part contribute to the chronic problems with aquatic vegetation which exist in this arm of the lake.

Dry and Wet Auglaize Creeks

Dry Auglaize Creek begins in the Central Plateau Region at Lebanon, Missouri and flows north for 54 miles through the Osage-Gasconade Hills Region before joining Wet Auglaize Creek near Toronto, Missouri (Figs. 0 and 3). Dry Auglaize Creek is a typical Ozark stream throughout its length. Stream habitat primarily resembled that found in the middle reaches of Maries and Gravois creeks. Substrate consists of varying sized chert and limestone fragments with smaller sand and gravel sizes predominating. The substrate

at Oad-1 was moderately stable, however, invertebrate production was higher than expected, averaging 119 organisms per square foot. Four discharges of treated sewage were identified in the headwater areas of Dry Auglaize Creek during 1975-76. These included Lebanon's northeast trickling filter plant (population equivalent (P.E.) = 7000; Table 1). In addition, 11 treated sewage effluents discharged into the headwaters of its major tributary, Goodwin Hollow Creek. Most of these discharges were from facilities serving mobile home parks in the Lebanon area (Table 1). One fish kill (800 fish) was documented in Goodwin Hollow Creek and two kills (28,000 and 6,500 fish, respectively) in Dry Auglaize Creek since 1970. All three kills resulted from overloading of the sewage treatment facilities serving Lebanon (Ryck 1973a, 1976b; Czarnezki 1981). The sampling site, Oad-1, located near the mouth of Dry Auglaize Creek, showed no effects from the problems in the headwaters, over 40 miles upstream (Fig. 3, Table 2). The water quality at this site was classified unpolluted based on benthic invertebrate community characteristics (Fig. 14, Appendix Table A-9) which met or exceeded criteria for Missouri streams and a diverse invertebrate community consisting of numerous pollution sensitive taxa (Fig. 15). The invertebrate community at Oad-1 was similar to 17 sites (Appendix Table A-23). Eighty-eight percent of these similar sites were on streams within the Ozark Highland Province (Fig. 0). The midge-mayfly-caddisfly dominant community at Oad-1 clustered with 18 other sites including previously discussed sites on Maries River (Oma-11, Oma-29), Gravois Creek (Ogv-12, Ogv-17) and the Osage River (0-33, 0-183, 0-208, 0-238, 0-271). The community at the two sites on Gravois Creek were aligned very close to the community in Dry Auglaize Creek. This community consisted of:

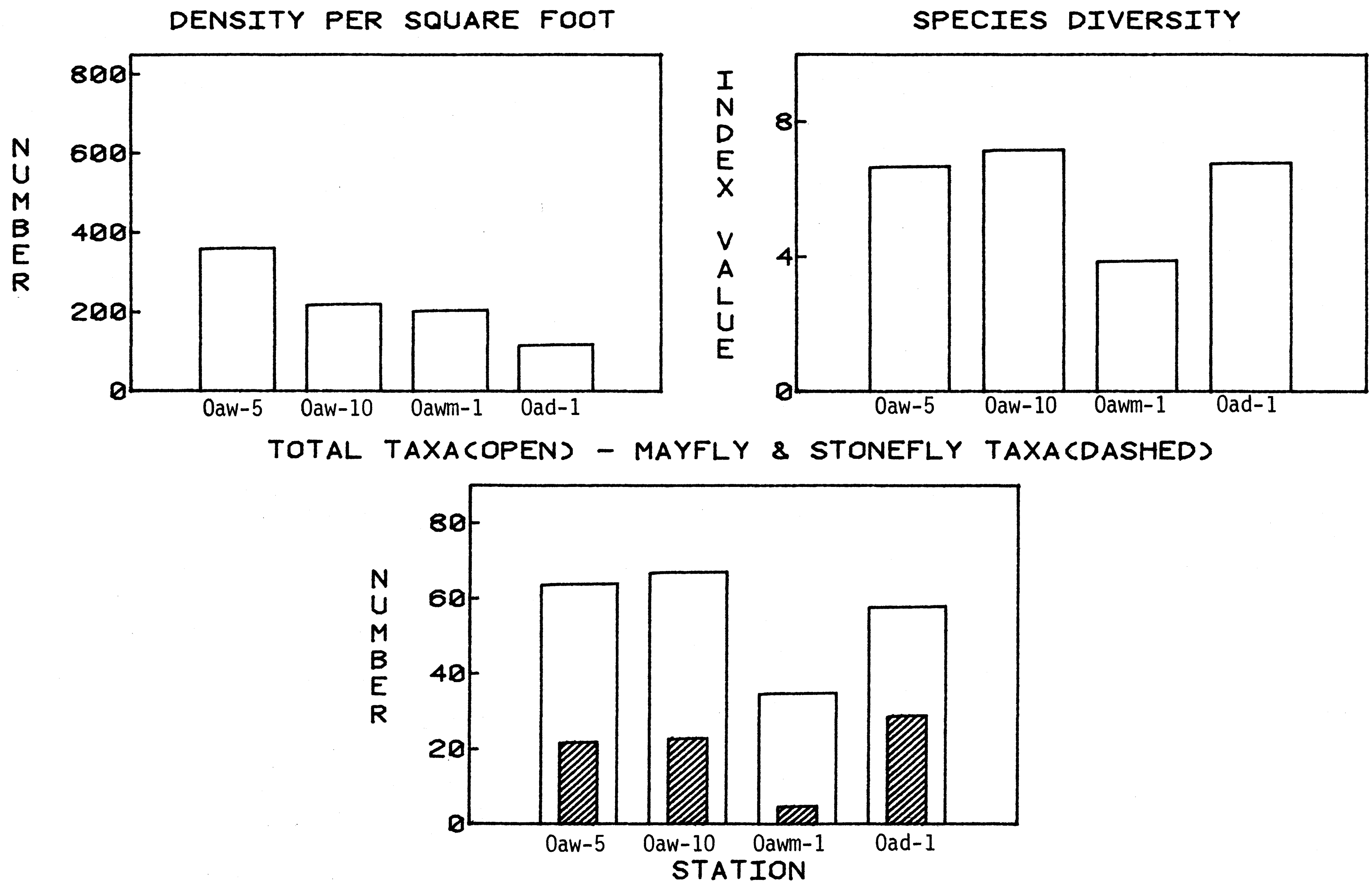


FIGURE 14. BENTHIC INVERTEBRATE COMMUNITY CHARACTERISTICS FOR SAMPLES FROM THE WET AUGLAIZE, MILL, AND DRY AUGLAIZE CREEKS- 1975-76.

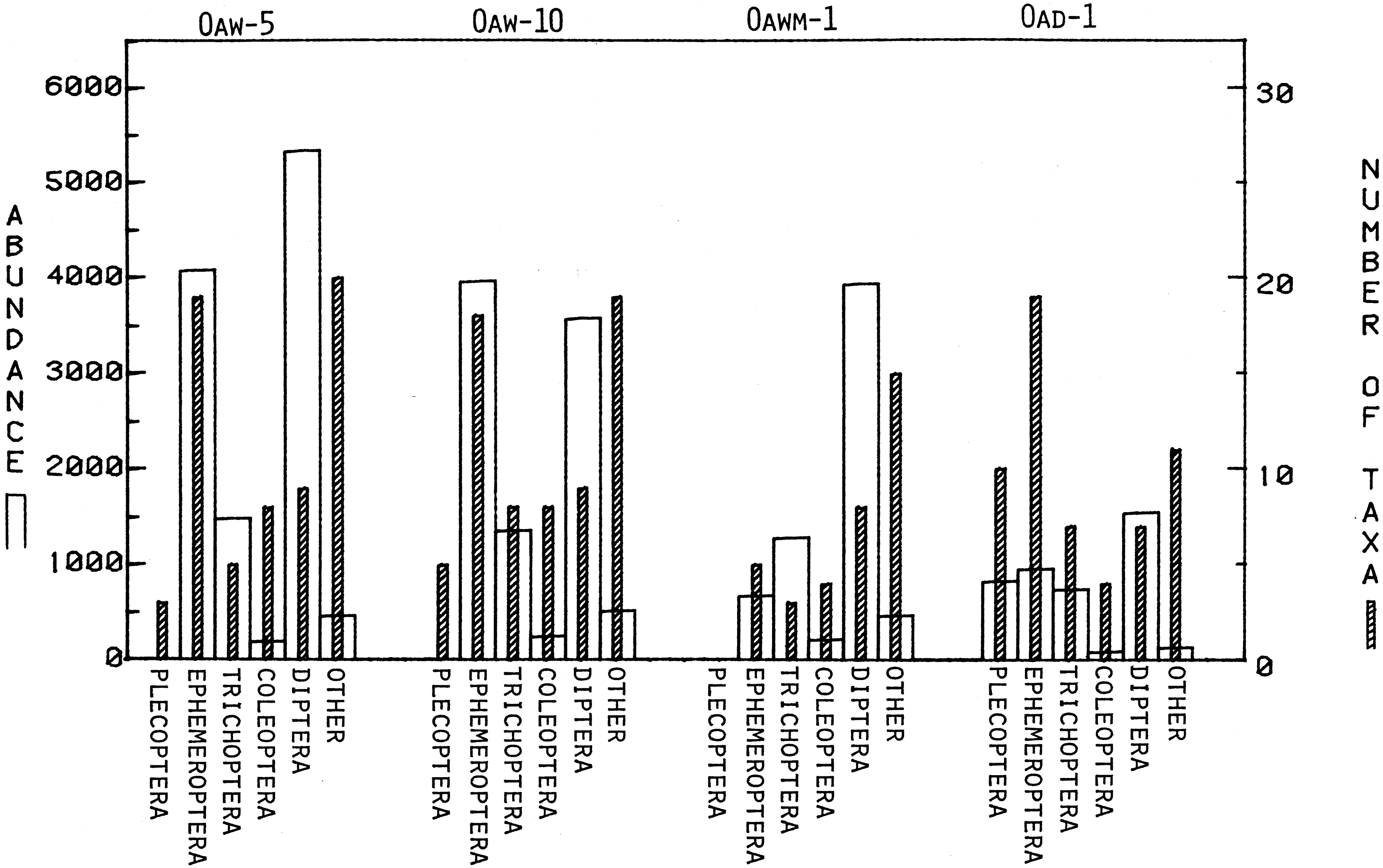


FIGURE 15. COMMUNITY STRUCTURE OF BENTHIC INVERTEBRATES BY ABUNDANCE AND TAXA FOR SAMPLES FROM THE WET AUGLAIZE, MILL, AND DRY AUGLAIZE CREEKS- 1975-76.

Flies (36%)		Mayflies (22%)		Stoneflies (19%)	
Chironomidae	91%	*Tricorythodes* sp.	53%	*Allocapnia* sp.	86%
Simuliidae	4%	*Baetis* sp.	11%	*Isoperla mohri*	4%
Atherix lantha	1%	*Pseudocloeon* sp.	11%	*Strophopteryx* sp.	3%
		Caenis sp.	7%		
		Caddisflies (17%)			
		Cheumatopsyche sp.	72%		
		Symphitopsyche bifida	15%		
		Agraylea sp.	5%		
		Lype sp.	5%		

Wet Auglaize Creek originates just west of Stoutland, Missouri in Camden County. It flows north for 38 miles through the Osage-Gasconade Hills Region before joining Dry Auglaize Creek and forming Grand Auglaize Creek (Fig. 0). Vineyard and Feder (1974) list six small springs discharging into branches and tributaries of Wet Auglaize Creek. They also list a small spring discharging into Grand Auglaize Arm of Lake of the Ozarks. Benthos samples were collected at three sites within the Wet Auglaize Creek Basin. One site (Oawm-1) was located on Mill Creek, a major tributary, and the other two on Wet Auglaize Creek, 5 miles (Oaw-5) and 10 miles (Oaw-10) above its confluence with Dry Auglaize Creek (Fig. 3, Table 2). Mill Creek entered Wet Auglaize Creek between these two sites. Aquatic habitat and stream substrate at the three sites were quite similar to that in Dry Auglaize Creek and other streams draining the Osage-Gasconade Hills Region. Water clarity was clear and bottom substrate was considered moderately stable because of the large amount of sand and gravel sized fragments of chert and limestone. The flora and fauna at these sites showed no obvious

influence from six springs which enter Wet Auglaize Creek at various locations. Discharges from hatchery ponds at Ozark Fisheries, Inc. enter Mill Creek and Wet Auglaize Creek downstream from Oaw-10 (Table 1).

Water quality in Wet Auglaize Creek at Oaw-10, upstream from these discharges, was classified unpolluted. Benthic invertebrate community characteristics consistently exceeded criteria for unpolluted Missouri streams on a sample and annual basis (Fig. 14, Table 3, Appendix Table A-9). The invertebrate community at this site consisted of a diverse assemblage of pollution sensitive taxa with all groups being well represented (Fig. 15). As seen below, mayfly, fly and caddisfly taxa were dominant:

Mayflies (41%)		Flies (37%)		Caddisflies (14%)	
Tricorythodes sp.	42%	Chironomidae	72%	Cheumatopsyche sp.	77%
Baetis sp.	15%	Simuliidae	26%	Symphitopsyche bifida	12%
Stenonema pulchellum	12%	Empididae	<1%	Agapetus sp.	1%
Caenis sp.	12%				

Water quality in Mill Creek at Oawm-1, downstream from the discharges from Ozark Fisheries, Inc., was quite different than that found at Oaw-10. Benthic invertebrate community characteristics were borderline between polluted and moderately polluted water quality. Very few pollution sensitive mayfly and no stonefly taxa were collected throughout the survey. This characteristic consistently fell in the polluted range on a seasonal and annual basis (Fig. 14, Table 3, Appendix Table A-9). A few pollution sensitive taxa, however, were collected in the other taxonomic groups. For this reason, water quality in Mill Creek below Ozark Fisheries, Inc. was classified moderately polluted. The degradation noted in Mill Creek was

associated with excessive nutrients discharged from the hatchery and not toxic compounds. The presence of some sensitive taxa, high benthos production (206 organisms per square foot), and heavy algal growths in the streams were the basis for this conclusion. Dominant invertebrate taxa collected at Oawm-1 were:

Flies (60%)		Caddisflies (19%)		Mayflies (10%)	
Simuliidae	72%	_Cheumatopsyche_ sp.	99%	_Caenis_ sp.	54%
Chironomidae	26%	_Symphitopsyche bifida_	<1%	_Tricorythodes_ sp.	40%
Empididae	<1%	_Chimarra obscura_	<1%	_Baetis_ sp.	5%

The effects of the discharges from Ozark Fisheries, Inc. were less evident at Oaw-5 on Wet Auglaize Creek. Benthos standing crop was quite high (362 organisms per square foot) and all community characteristics exceeded unpolluted criteria except _annual_ species diversity (Fig. 14, Table 3, Appendix Table A-9). A wide variety of pollution sensitive forms were present throughout the samples collected at this site (Fig. 15). Water quality in this reach of Wet Auglaize Creek was classified unpolluted and did not appear to be adversely affected by upstream discharges. The only evidence of enrichment was the high benthos production, heavy growths of aquatic macrophytes in pools, primarily _Ceratophyllum demersum_, and algae on the riffle substrate. Dominant taxa in samples from Oaw-5 were:

Flies (46%)		Caddisflies (35%)		Mayflies (10%)	
Simuliidae	72%	_Cheumatopsyche_ sp.	99%	_Caenis_ sp.	54%
Chironomidae	26%	_Symphitopsyche bifida_	<1%	_Tricorythodes_ sp.	40%
Empididae	<1%	_Chimarra obscura_	<1%	_Baetis_ sp.	5%

The benthos community in upper Wet Auglaize at site Oaw-10 was similar to those at 21 other sites in the Osage River Basin. Seventy-seven percent of these sites in this cluster were located within the Ozark Highland Province (Fig. 0) and included the other three sites on Wet and Dry Auglaize creeks (Appendix Table A-23). Benthos communities in Mill Creek and lower Wet Auglaize Creek were similar to those at 17 and 8 other sites, respectively. The similar communities were at sites primarily in the Western Plains Province (70% and 75%, respectively).

The benthos community from the headwaters of Wet Auglaize Creek (Oaw-10) clustered in the midge-mayfly-caddisfly groups along with Dry Auglaize Creek (Oad-1) and 13 Ozark Highland and three Western Plains province streams. The community at Oaw-10 was closest aligned to that near the mouth of Maries River (Oma-11). The benthos communities at Oawm-1 and Oaw-5, which received nutrient-rich discharges from Ozark Fisheries, Inc., were placed together in a different cluster which contained six other sites. Five of these sites were in the South Grand and Marais des Cygnes river basins in the Western Plains Province (Fig. 0). All sites in this cluster had invertebrate communities consisting of blackflies (Family Simuliidae) and Cheumatopsychid caddisflies (Appendix Table A-24). These two sites (Oaw-5 and Oawm-1) were most closely aligned with the upper site on the Marais des Cygnes River, Omdc-24 (Fig. 5).

Grand Auglaize Creek, formed at the confluence of Wet and Dry Auglaize creeks, was originally 24 miles long. Lake of the Ozarks inundated and eliminated 66% of this stream. Although no sampling sites were established on the 8 flowing miles of Grand Auglaize Creek which remain, there is no reason to suspect that water quality in this reach has changed from the unpolluted status near the mouths of its two major tributaries. No

pollution was identified discharging into these remaining 8 miles (Table 1).

Overall, the Auglaize system has quite high water quality and supports a diverse assemblage of pollution sensitive benthic invertebrates and fish. Three problem areas and sources of degradation were identified during the survey. They were:

1) Point source pollution and problems (fish kills) in the headwaters of Dry Auglaize and Goodwin Hollow creeks near Lebanon, Missouri.
2) Nutrient rich discharges into Mill and Wet Auglaize creeks from private fish culture activities.
3) Inundation and permanent loss of the lower 16 miles of Grand Auglaize Creek.

These problems appeared to be localized in the vicinity of the source and did not extend for great distances downstream as evidenced by diverse benthos communities at Oad-1 and Oaw-5. Only the loss of 66% of Grand Auglaize Creek was felt to be permanent. With proper abatement, the problems at Oawm-1 on Mill Creek and in the headwaters of the Dry Auglaize system can be solved.

Deer Creek

Deer Creek originates in the extreme southeast corner of Benton County (Fig. 3) and flows north for 23.5 miles across the Osage-Gasconade Hills Region (Fig. 0). Aquatic habitat in Deer Creek was considered typical of an Ozark stream. Substrate in Deer Creek was quite stable, consisting of limestone and chert fragments of varying size. Larger rubble sizes were more prevalent at this sampling site (Od-6) than in previously discussed streams. Water clarity was clear and temperatures were moderate. Diatoms were the primary plant growth on the substrate and water willows, *Justicia americana*, lined the margins of the riffles. Vineyard and Feder (1974) list

one very small spring, Bubbling Spring, in the Deer Creek Watershed. It enters Deer Creek about 9 miles upstream from Od-6 (Fig. 3, Table 2). The influence of Bubbling Spring on Od-6 was considered negligible since the daily discharge from the spring was only 52,000 gallons per day. Pollution sources in the watershed were limited to a small private lagoon which discharged into the headwaters of Deer Creek (Table 1). As in previous minor mainstem tributaries, the major alteration affecting Deer Creek was the permanent inundation of the lower 3.5 miles (15%) by the Deer Creek Arm of Lake of the Ozarks.

The benthic invertebrate community in Deer Creek at Od-6 consisted of many pollution intolerant taxa. This community was considered quite diverse and representative of unpolluted conditions (Fig. 16). Benthic invertebrate community characteristics were consistently above minimum criteria for unpolluted streams and were the basis for Deer Creek's unpolluted classification (Fig. 17, Table 3, Appendix Table A-9). Eighteen sites had similar invertebrate communities to those in Deer Creek. A vast majority (83%) of these communities were Ozark-type streams, primarily in the Sac, Pomme de Terre, and Niangua river basins (Appendix Table A-23). The community at Od-6 clustered with eight other Ozark streams, most having mayfly (*Stenonema* sp.), fly (Family Chironomidae), beetle (*Optioservus* sp.) communities (Appendix Table A-24). As noted below, the community in Deer Creek did not closely fit this cluster. Although a variety of aquatic beetles were present in Deer Creek, their abundance was low. Dominant taxa by abundance in Deer Creek were:

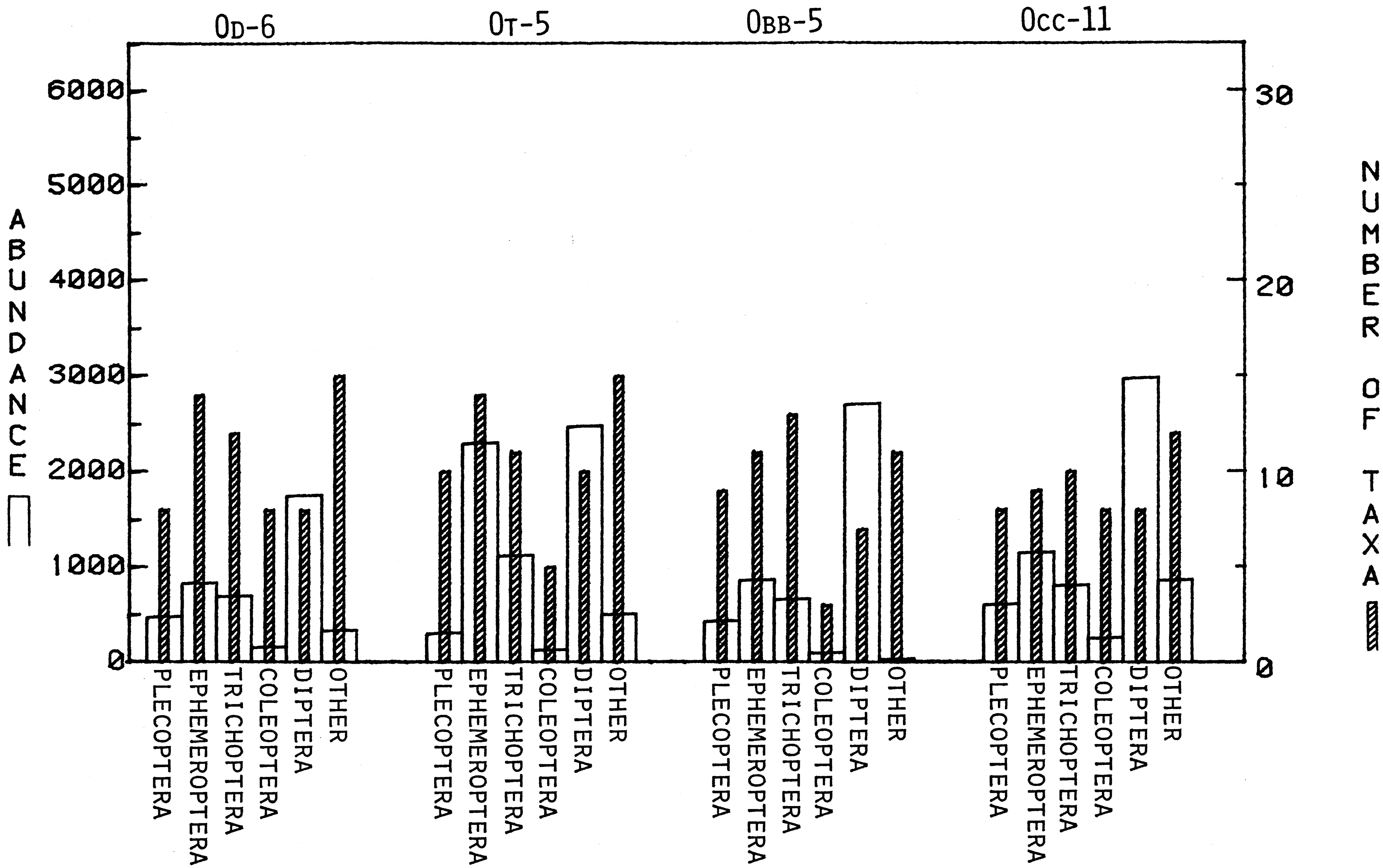


FIGURE 16. COMMUNITY STRUCTURE OF BENTHIC INVERTEBRATES BY ABUNDANCE AND TAXA FOR SAMPLES FROM DEER, TURKEY, BIG BUFFALO AND COLE CAMP CREEKS- 1975-76.

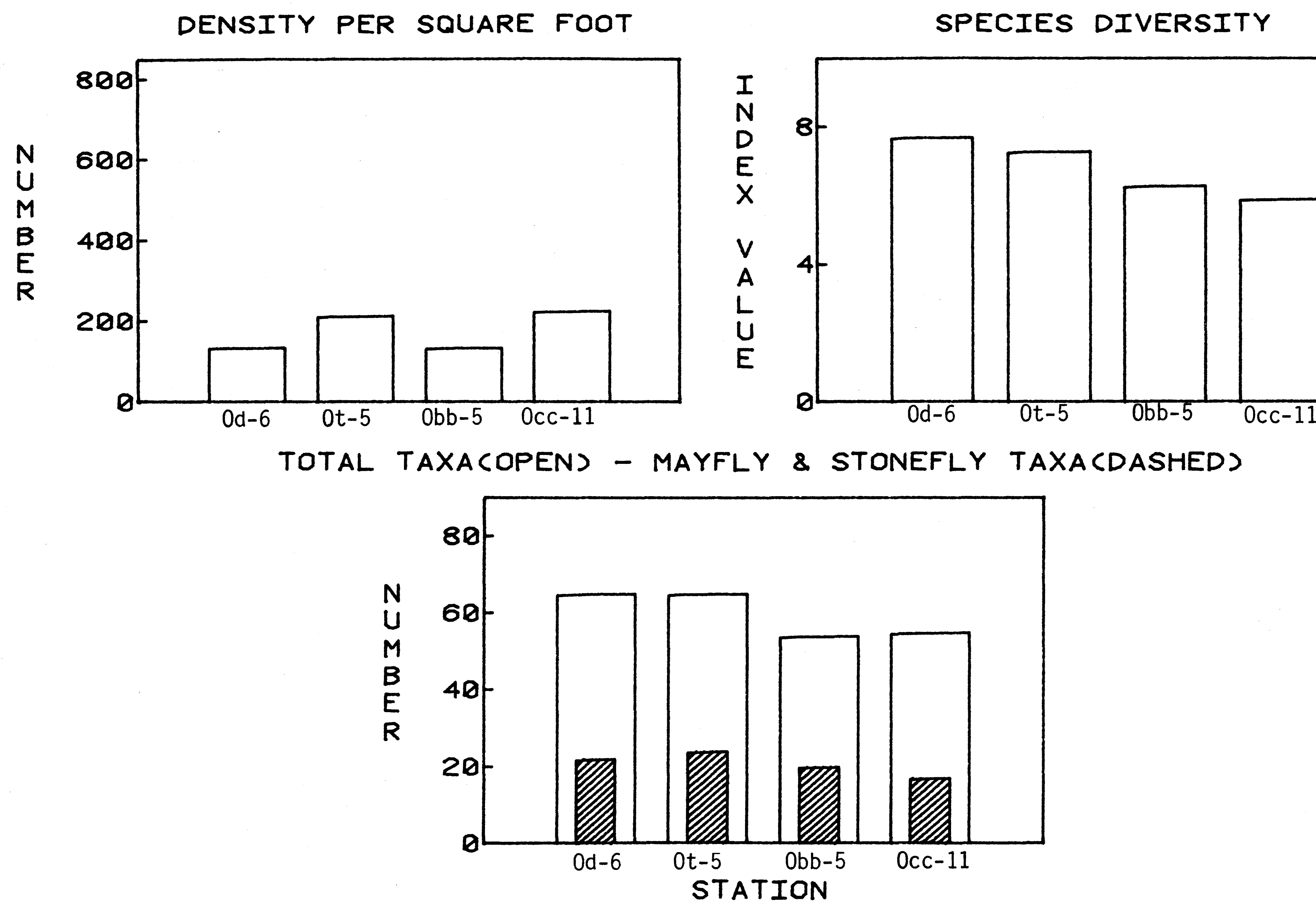


FIGURE 17. BENTHIC INVERTEBRATE COMMUNITY CHARACTERISTICS FOR SAMPLES FROM DEER, TURKEY, BIG BUFFALO, AND COLE CAMP CREEKS- 1975-76.

Flies (41%)		Mayflies (20%)		Caddisflies (16%)	
Chironomidae	56%	*Pseudocloeon* sp.	25%	*Agapetus* sp.	56%
Simuliidae	35%	*Stenonema pulchellum*	17%	*Cheumatopsyche* sp.	27%
Bezzia/ Probezzia, ...,	4%	*Isonychia* sp.	16%	*Hydroptila* sp.	6%
		Caenis sp.	11%		
		Stoneflies (11%)			
		Nemoura sp.	63%		
		Strophopteryx sp.	26%		
		Hastaperla brevis	4%		

Turkey Creek

Aquatic habitat in Turkey Creek was similar to that found in Deer Creek. Substrate, water clarity, aquatic plant growth, and other features were very similar. No springs were listed in the basin (Vineyard and Feder 1974). A gravel operation, located about 2 miles upstream from Ot-5 (Fig. 3, Table 2), was the only pollution source identified in the Turkey Creek Basin during the survey (Table 1). The benthos community in Turkey Creek showed no obvious degradation associated with this operation. Community characteristics were high and for the most part exceeded criteria for unpolluted streams throughout the survey (Fig. 17, Table 3, Appendix Table A-9). These characteristics and the wide variety of benthic taxa (Fig. 16) were the primary reason for classifying the water quality in Turkey Creek as unpolluted. The invertebrate community at Ot-5 was comprised primarily of midges, Tricorythid mayflies, and Cheumatopsychid caddisflies. Analyses clustered this community with 17 other sites with this structure (Appendix Table A-24). The community in Turkey Creek was considered quite cosmopolitan, being similar to 28 other sites. This is the third largest number of

similarities in the Osage River Basin. Seventy-five percent of these sites were on Ozark Highland Province streams (Appendix Table A-23). Common taxa at Ot-5 were:

Flies (36%)		Mayflies (34%)		Caddisflies (16%)	
Chironomidae	79%	*Tricorythodes* sp.	25%	*Cheumatopsyche* sp.	63%
Bezzia/ Probezzia, ...,	11%	*Stenonema pulchellum*	21%	*Chimarra obscura*	21%
Simuliidae	9%	*Caenis* sp.	16%	*Hydroptila* sp.	9%
		Pseudocloeon sp.	9%		
		Other (17%)			
		Oligochaeta	77%		
		Planariidae	17%		
		Orconectes sp.	1%		

The permanent inundation of the lower 4 miles (12%) of Turkey Creek by the Lake of the Ozarks was the primary adverse activity identified in its watershed during this survey. Flowing portions of Turkey Creek did not appear to have any problems.

Big Buffalo Creek

Big Buffalo Cove of Lake of the Ozarks occupies the lower 20% (3 miles) of its original stream mileage. The stream begins in Morgan County, south of Stover, Missouri, and flows south 16 miles before entering the Osage River near Old Zora, Missouri. Sampling site Obb-5 was established upstream from a low water crossing near the Benton-Morgan County line (Fig. 3, Table 2). Above this site, Big Buffalo Creek drains about 24 square miles and had an average discharge of 20.5 cubic feet per second over 12 years (U.S. Geological Survey 1977). Boyler's Mill Spring enters Big Buffalo Creek from the north,

about 1.5 miles upstream from Obb-5. According to Vineyard and Feder (1974), flow in Boyler's Mill spring averages about 0.8 million gallons per day. Fajen (1959) reported that of the 13 miles of Buffalo Creek not inundated by Lake of the Ozarks, 6 miles maintain permanent flow. During dry years, Boyler's Mill Spring makes up most of this flow.

In 1963, the Missouri Department of Conservation purchased 1436 acres of land just upstream from Obb-5. This area was named Big Buffalo Creek Wildlife Area and the 1.3 miles of stream on the area have been used as a research area to study the effects of stream habitat alterations and management. Prior to 1963, the stream channel of Big Buffalo Creek had been straightened. After its purchase, portions of the stream channel were re-routed in an attempt to promote stream channel stability. Ultimately, it was hoped that the stream would return to near its original productivity and appearance. These objectives, for the most part, were met, especially, the increase of fish production and diversity (Fajen 1973a, 1973b).

In 1968, another study was started to determine the effects of unstable substrate and scouring floods on the benthos community in Big Buffalo Creek. During the process of stabilization, Big Buffalo Creek experienced periods when heavy runoff (greater than a 3 foot raise in gauge height) transported large quantities of substrate, scoured established riffles and disrupted the existing invertebrate communities. This study showed that the benthos community returned to pre-scoured density, diversity and structure within 1 month following each flood (Ryck 1975a). These findings become very important when the effects of pollution on water quality are being assessed using aquatic invertebrates.

The substrate at Obb-5 was considered quite stable. Benthic invertebrate community characteristics (Fig. 17, Appendix Table A-9) consistently approached criteria for unpolluted streams (Table 3) throughout the survey. No pollution

sources were detected in the basin (Table 1). The only adverse activities found in the basin were the inundation of the lower 3 miles and the channel straightening which occurred prior to 1963. The benthos community in Big Buffalo Creek consisted of a variety of pollution sensitive taxa (Fig. 16) and was quite similar to that found in Turkey and Gravois creeks. Water quality in Big Buffalo Creek was considered unpolluted primarily because of the variety and types of taxa present. Its similarity with 20 other sites in the Osage River Basin with good water quality strengthened this judgement. The influence of ground water from Boyler's Mill Spring tended to decrease the community characteristics for samples from Obb-5. This depression of community characteristics has been observed in other Ozark Highland Province streams which are unpolluted and whose flow consisted primarily of spring water (Duchrow 1977). Major taxa at Obb-5 consisted of:

Flies (56%)		Mayflies (18%)		Caddisflies (14%)	
Chironomidae	92%	*Pseudocloeon* sp.	57%	*Cheumatopsyche* sp.	62%
Simuliidae	6%	*Baetis* sp.	14%	*Symphitopsyche bifida*	27%
Empididae	1%	*Tricorythodes* sp.	13%	*Helicopsyche* sp.	4%
		Stoneflies (9%)			
		Isoperla spp.	36%		
		Hastaperla brevis	24%		
		Amphinemura/Prostoia	20%		
		Neoperla sp.	7%		
		Strophopteryx sp.	7%		

The dominance of these taxa clustered the benthos community at Obb-5 with those at Ot-5 and others with midge-mayfly-caddisfly communities

(Appendix Table A-24). The community at Obb-5 was most closely aligned with that at O-33 on the mainstem Osage River near St. Thomas, Missouri (Fig. 3).

Cole Camp Creek

Cole Camp Creek is the next basin west of Big Buffalo Creek. As in Big Buffalo Creek, the entire 35 miles of Cole Camp Creek lie within the Osage-Gasconade Hills Region (Fig. 0). This stream begins at Cole Camp, Missouri (Benton County) and joins the Osage River from the north, 3 miles west of Lakeview Heights. Treated sewage effluent from Cole Camp (P.E.=1000), Lincoln (P.E.=870), and a small subdivision (P.E.=15) are discharged into Cole Camp Creek between 6 and 12 miles upstream from Occ-11 (Fig. 3, Tables 1 & 2). In addition, a gravel dredging operation was located about 1 mile upstream from the sample site (Table 1). The lower 6 miles (17%) form Cole Camp Arm of Lake of the Ozarks. The substrate at Occ-11 was quite stable and consisted of a variety of rubble and smaller sized limestone and chert fragments. Benthos standing crop was moderately high, averaging 224 organisms per square foot. The periodic heavy growths of filamentous algae and high benthos production suggest an influence from the nutrient-rich discharges in the headwaters. Benthic invertebrate community characteristics were primarily in the moderately polluted range (Fig. 17, Appendix Table A-9, Table 3), which indicates some water quality degradation. Community structure of invertebrates in samples from Cole Camp Creek consisted of both pollution tolerant and intolerant forms (Fig. 16). Sensitive forms were well represented in these samples. The community at Occ-11 clustered with ten others consisting primarily of midges (Family Chironomidae), biting midges (Family Ceratopogonidae), aquatic earthworms (Class Oligochaeta), and mayflies having medium to high sample densities (Appendix Table A-24). Several of the sites in this cluster

also receive and are adversely affected by discharges of treated sewage effluent. For these reasons, the water quality in Cole Camp Creek at Occ-11 was classified moderately polluted. The presences of sensitive taxa during portions of the year indicate that conditions were not highly toxic and only periodic in their degrading effects. Common taxa at Occ-11 were represented by:

Flies (59%)		Mayflies (13%)		Other (10%)	
Chironomidae	91%	_Caenis_ sp.	55%	Oligochaeta	95%
Bezzia/ Probezzia, ...,	6%	_Baetis_ sp.	14%	_Ferrissia_ sp.	1%
Simuliidae	1%	_Pseudocloeon_ sp.	10%	Acari	1%
		Stenonema pulchellum	8%		

Removal of sewage treatment effluents from the headwaters of Cole Camp Creek would improve water quality in this stream. Although the degradation was not as severe as it could be, the physical habitat present has the potential of supporting a healthy, more diverse community of pollution sensitive invertebrates.

Clear Creek

Clear Creek was the only order 6 stream included in the minor mainstem tributary subsection of the Osage River Basin. The other streams were order 4 and 5 streams. Clear Creek is a prairie stream. It's entire basin lies within the Cherokee Plains Region of the Western Plains Province (Fig. 0). This stream begins in southern Vernon County near Sheldon, Missouri and flows northeast for 59 miles before joining the Osage River east of Taberville, Missouri in St. Clair County (Fig. 4). Agriculture and surface mining are

more common land uses in the Cherokee Plains Region than in the regions of the Ozark Highland Province (See Description of the Study Area). This held true in the Clear Creek Basin and problems from non-point sources were more evident than in previously discussed minor mainstem tributaries. In addition, Clear Creek received treated sewage effluent at various locations throughout its course (Table 1). During this survey, six such sources were identified. These included lagoon effluent from a National Guard camp discharging into the upper reaches (P.E.=8000), effluent from El Dorado Springs (P.E.=7500) located 7 miles upstream from Oc-10, and several smaller facilities (Table 1, Fig. 4, Table 2). A limestone quarry and an area of abandoned strip mine land were also located within the basin and posed a potential pollution threat (Table 1). Finally, the completion of Truman Reservoir in 1978, permanently inundated the lower 4 miles (7%) of Clear Creek and placed an additional 7 miles (12%) within the reservoir's flood pool.

Oc-10 was located within the flood pool, 10 miles above the confluence with the Osage River (Table 2). Varying sized fragments of shale comprised the substrate in the small stable riffle at this site. Certain portions of the habitat at Oc-10 also consisted of shale bedrock overlain by silt. Water clarity was slightly to moderately turbid during each collection and water temperature was considered moderate. A water sample collected in 1973 by Kersh (1977) quantified these descriptions. Most values in Appendix Table A-2 were considered normal. Phosphates, however, were higher than the other minor mainstem tributaries sampled, turbidity was slight (7 Jackson Turbidity Units) and the water appeared softer than normal (Alkalinity = 90 milligrams per liter $CaCO_3$). A combination of artificial substrate samplers (Fig. 2) and the riffle net were used to collect each sample because

of the varied aquatic habitat present. Benthic invertebrate community characteristics for these samples were consistently in the moderately polluted range (Fig. 18, Appendix Table A-9, Table 3). Invertebrate density was high, averaging 235 organisms per square foot and the community consisted primarily of pollution tolerant midges and aquatic oligochaetes (segmented worms). Sensitive taxa were present but quite limited in abundance (Fig. 19). Dominant taxa at Oc-10 consisted of:

Flies (58%)		Other (30%)		Caddisflies (7%)	
Chironomidae	95%	Oligochaeta	93%	*Cyrnellus* sp.	44%
Simuliidae	3%	Hirudinea	3%	*Cheumatopsyche* sp.	40%
Culicoides sp.	1%	*Argia* sp.	1%	*Polycentropus* sp.	11%

Based on the above data, the water quality was classified moderately polluted. The causes were a combination of effects from point and non-point sources. The benthos community in Clear Creek was similar to 12 sites of which about 67% were on prairie streams (Appendix Table A-23). This community was grouped in the same cluster as Cole Camp Creek and the headwaters of Maries River. Basically, this cluster contained communities affected by treated domestic sewage including Cole Camp Creek, the headwaters of Maries and the Little Sac rivers, and the East Fork of Tebo Creek (Appendix Table A-24). Water quality degradation resulting from inadequate or overloaded facilities in Clear Creek and these other streams will continue if present levels of abatement are not increased.

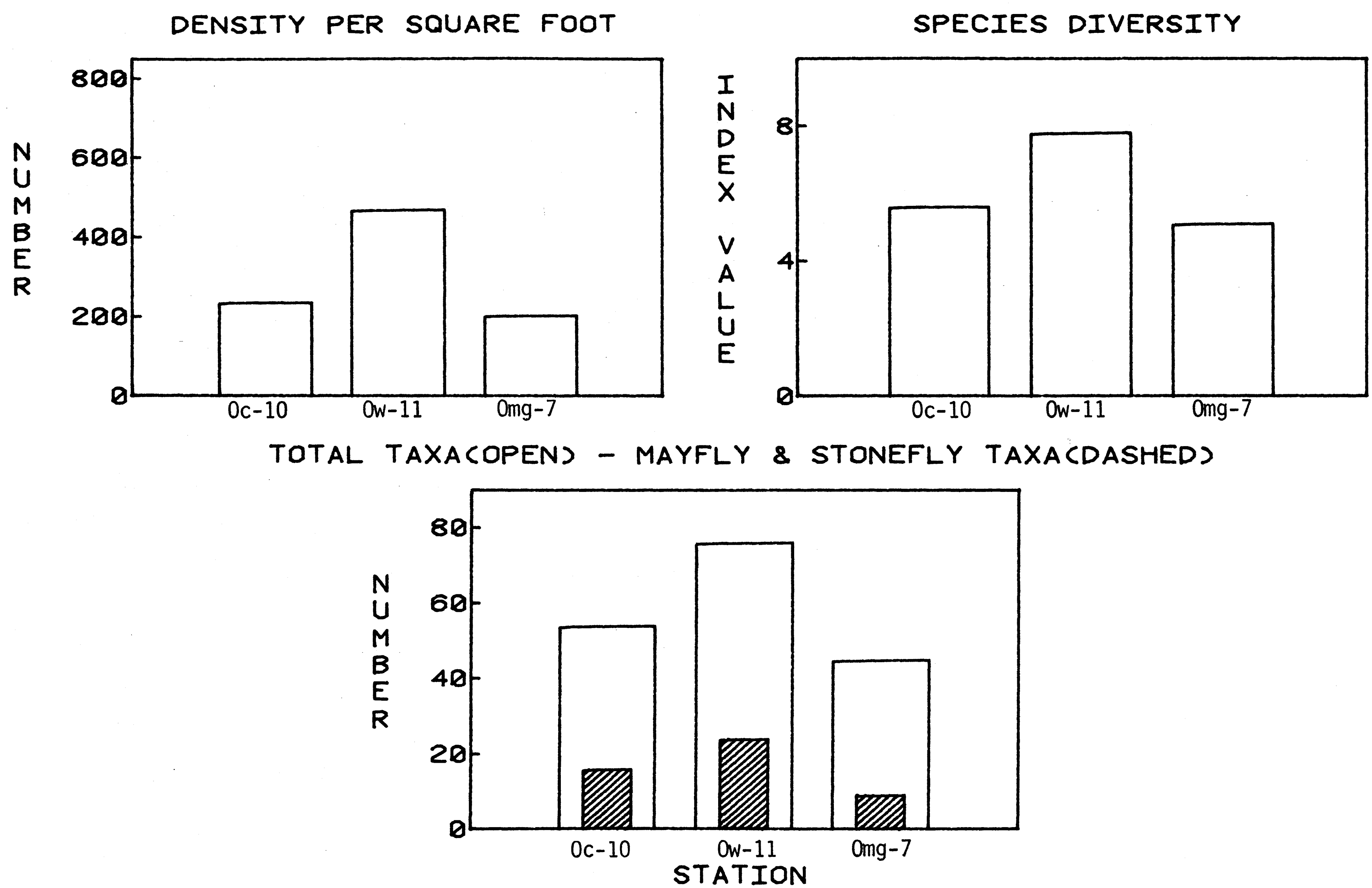


FIGURE 18. BENTHIC INVERTEBRATE COMMUNITY CHARACTERISTICS FOR SAMPLES FROM CLEAR, WEAUBLEAU, AND MONEGAW CREEKS- 1975-76.

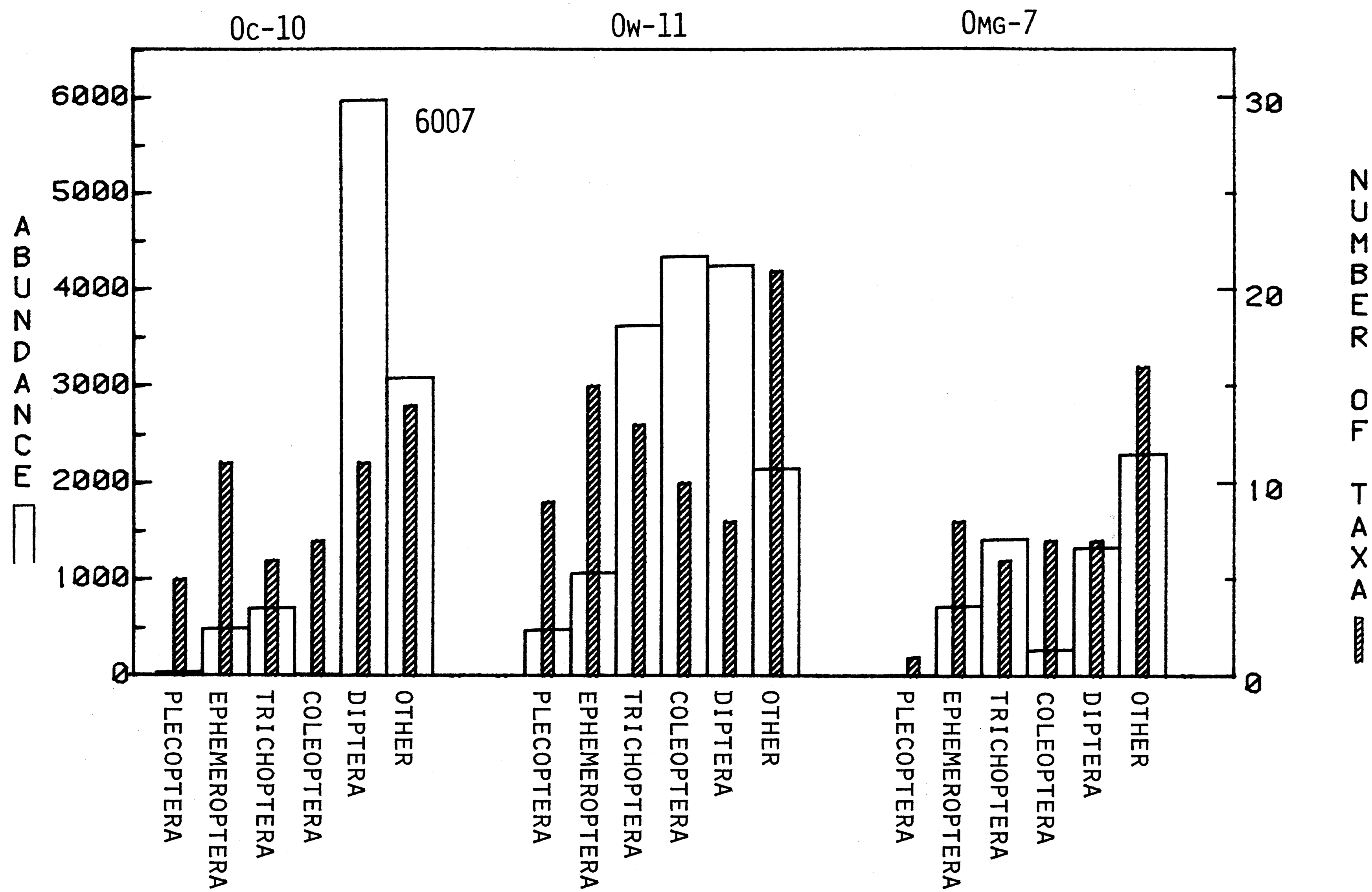


FIGURE 19. COMMUNITY STRUCTURE OF BENTHIC INVERTEBRATES BY ABUNDANCE AND TAXA FOR SAMPLES FROM CLEAR, WEAUBLEAU, AND MONEGAW CREEKS- 1975-76.

Weaubleau Creek

The Weaubleau Creek Basin lies completely within the Springfield Plain Region of the Ozark Highland Province (Fig. 0). Streams in this region are considered transitional or intergrade between the prairie streams of the Western Plains Province and the warm-water mountain type streams of the Ozark Highland Province. Dissection of the topography in the watershed of Weaubleau Creek and other intergrade streams is also intermediate between the two provinces. Likewise, rowcrop agriculture is less intense, tending toward the production of livestock. Problems associated with intensive agriculture are also less severe. No point sources of pollution were identified in the Weaubleau Creek Basin (Table 1). The stream begins in southwest Hickory County near Weaubleau, Missouri and flows north for 39 miles before joining the Osage River just east of Osceola (Fig. 4). Two very small springs, Cave and Blue Stem, discharge into the headwaters of Weaubleau Creek (Vineyard and Feder 1974). These springs contribute little to the overall flow even during dry weather. Physically and chemically (Appendix Table A-2), the aquatic habitat at Ow-11 (Fig. 4, Table 2) resembled other Ozark Highland Province streams. Riffle substrate consisted of chert and limestone fragments varying in size from sand to rubble. Riffles were quite stable and afforded good habitat for invertebrate production. Water clarity was clear and temperatures moderate. Water willow (Justicia americana) was abundant in the riffle margins and diatoms covered the substrate. Benthos production at Ow-11 was very high, averaging 468 organisms per square foot (Fig. 18). This was the third highest average sample density recorded in the Osage River Basin. Included in this high production of benthos was a large variety of invertebrate taxa including many sensitive forms (Fig. 19). Likewise, benthic invertebrate community characteristics were also high (Fig. 18, Appendix Table A-9). They exceeded

criteria for unpolluted streams in all categories (Table 3). Water quality in Weaubleau Creek was classified unpolluted. Good populations of several naiad species (Phylum Mollusca) were also found. The most abundant taxa at Ow-11 were:

Beetles (27%)		Flies (27%)		Caddisflies (23%)	
Stenelmis sp.	98%	Chironomidae	62%	*Chimarra obscura*	43%
Psephenus herricki	1%	Simuliidae	35%	*Cheumatopsyche* sp.	36%
Dubiraphia sp.	1%	*Bezzia*/ *Probezzia*, ...,	2%	*Ochrotrichia* sp.	14%
				Agapetus sp.	1%
		Other (13%)			
		Planariidae	49%		
		Oligochaeta	29%		
		Sphaeriidae	10%		

The invertebrate community in Weaubleau Creek at Ow-11 was quite unique. It was similar in structure to those at five other sites in the Osage River Basin including two Ozark, two intergrade, and one prairie stream (Appendix Table A-23). The aquatic beetle-midge community in Weaubleau Creek clustered with those at the two sites on Lindley Creek in the Pomme de Terre River Basin.

The permanent flooding of the lower 3.5 miles (9%) by Truman Reservoir and the inclusion of another 3.5 miles (9%) of Weaubleau Creek in its flood plain were the only alterations documented during the survey. It will be important to protect this stream in the future since many of its features are unique.

Monegaw Creek

The lower 11 miles (45%) of Monegaw Creek have been included in Harry S.

Truman Reservoir. Fourteen percent of this mileage is permanently inundated under the conservation pool and the remaining 31% (7.5 miles) is encompassed by the flood pool. The entire 24 miles of this prairie stream flow within the Cherokee Plains Region (Fig. 0). The Monegaw Creek Basin is one of the many watersheds in the Cherokee Plains Region that has large deposits of coal near the land surface. Most of the abandoned and present active mining in the Monegaw Creek Basin are located near the headwaters (Table 1). Consequently, this stream has had a history of pollution problems associated with acid runoff from poorly reclaimed strip mine lands which date back to 1951. A water sample collected at Omg-7 in 1973 by Kersh (1977) had much higher than normal values for specific conductance and sulfates (Appendix Table A-2). These high values are directly related to acid runoff from these abandoned lands. Fishkills in the upper portions of Monegaw Creek during 1970 and 1975 brought these problems to a head (Ryck 1973b, 1976b). Pittsburg and Midway Coal Company were responsible for the unreclaimed land. Reclamation work completed by them in 1976 has prevented the recurrence of fishkills to date, however, more work would be necessary to eliminate these potential sources. In addition, treated sewage effluent from an overloaded lagoon serving Appleton City, Missouri (P.E.=1325) enters the headwaters of Monegaw Creek (Table 1).

At the beginning of the survey, the sample site (Omg-7) was located at a stable riffle consisting of varying sizes of limestone (Fig. 5, Table 2). Water clarity was variable, temperatures moderate and the substrate was normally covered with a moderate growth of periphyton. Since Omg-7 was located within the flood pool elevation of Truman Reservoir, bridge construction during the winter and spring of 1976 by the U.S. Army Corps of Engineers severely altered the terrestrial and aquatic habitat in the area. Benthic invertebrate community characteristics, however, did not reflect degradation beyond that which already existed (Appendix Table A-9).

All characteristics consistently fell within the moderately polluted range throughout the survey (Fig. 18, Table 3). Although some pollution sensitive invertebrate taxa were collected, the majority were facultative and tolerant forms (Fig. 19). Water quality was therefore classified moderately polluted. The invertebrate community at Omg-7 was similar to nine other sites in the Osage River Basin (Appendix Table A-23). Four of these communities were on prairie streams, four on intergrade and one on an Ozark stream. The community at Omg-7 was closely aligned with that in Brush Creek (Osbh-3, Fig. 4), an order 5, intergrade stream in the Sac River Basin (Appendix Table A-24). These two communities were dominated by Oligochaetes, fingernail clams (Family Sphaeriidae), and midges. Other taxa included:

Other (38%)		Caddisflies (23%)		Flies (22%)	
Oligochaeta	79%	*Cheumatopsyche* sp.	98%	Chironomidae	95%
Sphaeriidae	14%	*Chimarra obscura*	1%	*Bezzia/ Probezzia*, ...,	4%
Hyalella azteca	4%	*Agraylea* sp.	<1%	Simuliidae	<1%
		Mayflies (12%)			
		Caenis sp.	87%		
		Stenacron interpunctatum	7%		
		Stenonema femoratum	5%		

The influence of Truman Reservoir on the lower 45% of Monegaw Creek and the discharge of pollutants from point and non-point sources into the headwaters limit the possibilities of improved water quality in the near future. Improvements which may occur in the future can only have positive effects on this stream.

Overall, the water quality at the 20 sites on these 11 minor mainstem tributaries was quite good. Eight of these streams basins drained the Ozark Highland Province and were considered representative of Ozark streams. Water quality at a majority of these sites was classified unpolluted. Organic loading from point sources of pollution, primarily treated sewage effluent, was the major cause of degradation noted in these streams. The headwaters of Maries River, most of Mill Creek, and Cole Camp Creek were affected by this loading and classified moderately polluted. Weaubleau Creek flowed through a transition zone between the Ozarks and prairie. It was considered an intergrade stream. Water quality in Weaubleau Creek was quite high and classified unpolluted. The remaining streams, Clear and Monegaw creeks, were prairie streams. In addition to organic loading from point sources, non-point pollution from agriculture and surface mining compounded problems. Water quality in both streams was classified moderately polluted.

The inundation of the lower reaches of most of these streams by the construction of Lake of the Ozarks and Harry S. Truman Reservoir had very serious impacts on these streams. The habitat in these reaches was permanently changed from lotic to lentic and could no longer function as a productive riverine ecosystem. The impacts from this change becomes more serious when streams with unique features like Weaubleau Creek are altered. A total of 72.5 miles (19%) in nine of the minor mainstem tributaries was eliminated by flooding. Reaches on Maries River and Tavern Creek were not altered since they enter the Osage River below these impoundments.

The invertebrate communities at the 20 sites were grouped in eight different clusters based primarily on simularities in commmunity structure. The 15 sites whose water quality was classified unpolluted were placed in six clusters. Most of these sites (14) were located on Ozark streams and

were included in clusters containing sites on other Ozark streams. Of these, eight sites (Oma-29, Oma-11, Ogv-12, Ogv-17, Oad-1, Oaw-10, Ot-5, and Obb-5) were aligned in the same cluster based on a large number of midges, Tricorythid mayflies, and Cheumatopsychid caddisflies. The other six Ozark sites were placed in four different clusters. These four clusters had large numbers of pollution sensitive taxa, primarily mayflies and stoneflies, as dominant types. The other unpolluted site was located on Weaubleau Creek, an intergrade stream. It's community was dominated by Elmid beetles and midges. This structural type aligned with that at the two sites on Lindley Creek, a small Ozark stream in the Pomme de Terre River Basin.

The five sites with moderately polluted water quality were placed in three clusters. Pollution tolerant taxa were dominant in these clusters. Sites included in these clusters were mostly prairie and intergrade streams with many having problems associated with organic enrichment.

Point and non-point pollution and channelization caused degradation in a minimum of 19.5 miles of these minor mainstem tributaries (Missouri Department of Conservation 1978). This and the loss of 72.5 miles of these streams by inundation has adversely affected about 19% of the total stream mileage in these basins. Effective pollution abatement can reduce these losses to 15%. Of equal importance is the protection of the 53 miles of the Maries River and Tavern Creek which support populations of Niangua Darter. This species has been recommended for designation as a nationally threatened species. Thirty miles of its known habitat in Tavern Creek has also been designated as critical habitat for this species (Pflieger 1978).

Marais des Cygnes River

Prior to 1906, 57 miles of the Marais des Cygnes River flowed between

the Kansas state line and its confluence with the Marmaton River in southeastern Bates County (Fig. 5). The construction of the Bates County Drainage Ditch between 1906 and 1911 reduced this total length by 27 miles (41%) and left only 6 miles of the original stream intact. This means that this man induced alteration has permanently destroyed 89% of the original mainstem Marais des Cygnes River. Of the 30 miles which presently remain, 41% (12.5 miles) are within the flood pool of Truman Reservoir. The entire 12.5 miles are contained within the drainage ditch reach so the 6 unaltered miles remain intact.

The 30 miles of the Marais des Cygnes River in Missouri flow primarily across the Osage Plains Region of the Western Plains Province (Fig. 0). Surface mining for coal and rowcrop agriculture, discussed previously, are the major landuses and are responsible for many of the non-point problems threatening this stream.

The streams within the Marais des Cygnes River Basin support 53 species of fish representing 12 families (Table 4). This is low for a basin of this size. Only the Marmaton-Little Osage and South Grand river basins were less diverse, each having 52 species. A total of 110 taxa of aquatic invertebrates were collected at the five sampling sites during the survey (Table 5). Twenty-five taxa were pollution sensitive mayflies and stoneflies. This ranks the Marais des Cygnes River Basin, seventh and sixth, respectively, in the number of total and sensitive benthos taxa among the eight Osage River Basin subdivisions. The tremendous reduction of aquatic habitat diversity by channelization was largely responsible for these low values.

Marais des Cygnes River (Mainstem)

The Marais des Cygnes River was sampled at two sites. Omdc-24 was located at the Bates County Route V crossing (Fig. 5, Table 2), 24 miles

from the river's present confluence with the Marmaton River. Samples were primarily collected with a riffle net from a permanent, stable riffle located within the unchannelized 6 miles of the Marais des Cygnes River. Artificial substrate samplers were also installed at Omdc-24 because flow in this river is quite variable (U.S. Geological Survey 1978). Substrate in the riffle consisted of angular fragments of sedimentary rock. Although a variety of fragment sizes were present, the larger rock and rubble sizes made up a majority of the surface area. Artificial substrates were placed on clay hardpan overlain by silt. Water temperatures were moderate and periphyton growths at times were quite heavy. Water samples collected by the U.S. Geological Survey (1975) show very high values for bacteria and nutrients, especially nitrates during 1974-75 (Appendix Table A-3). The high periphyton production at Omdc-24 was an expression of this loading. Sources of this enrichment were not identified during the survey. Point and non-point problems from municipalities and agriculture entering along the 205 miles of the Marais des Cygnes River in Kansas are suspected. Only backwash from the Amoret, Missouri drinking water treatment plant enters the river about 3 miles upstream from Omdc-24 (Table 1). It is doubtful that this periodic discharge has any adverse effect on the water quality at Omdc-24. Benthos standing crop at this site was high, averaging 354 organisms per square foot (Fig. 20). Flies, primarily blackflies (Family Simuliidae) and net-spinning caddisflies (Family Hydropsychidae) comprised much of the community (60%) as seen in Figure 21. Benthic invertebrate community characteristics for samples from Omdc-24 approached and in many cases exceeded criteria for unpolluted Missouri streams (Appendix Table A-11, Table 3). Considering the influences of non-point pollutants on this prairie stream, the presence of good numbers of pollution sensitive mayflies

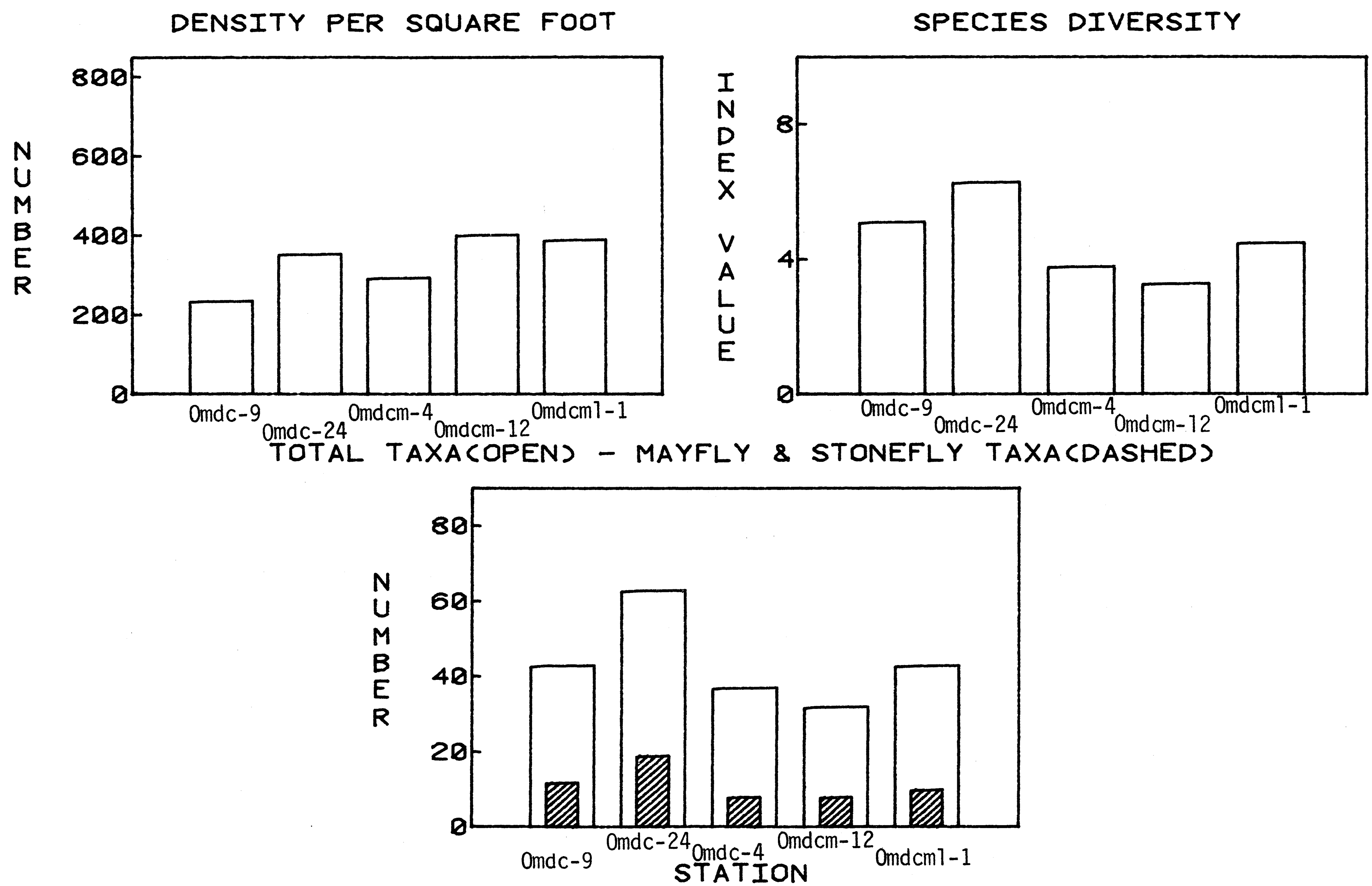


FIGURE 20. BENTHIC INVERTEBRATE COMMUNITY CHARACTERISTICS FOR SAMPLES FROM THE MARAIS DES CYGNES RIVER AND MIAMI CREEK- 1975-76.

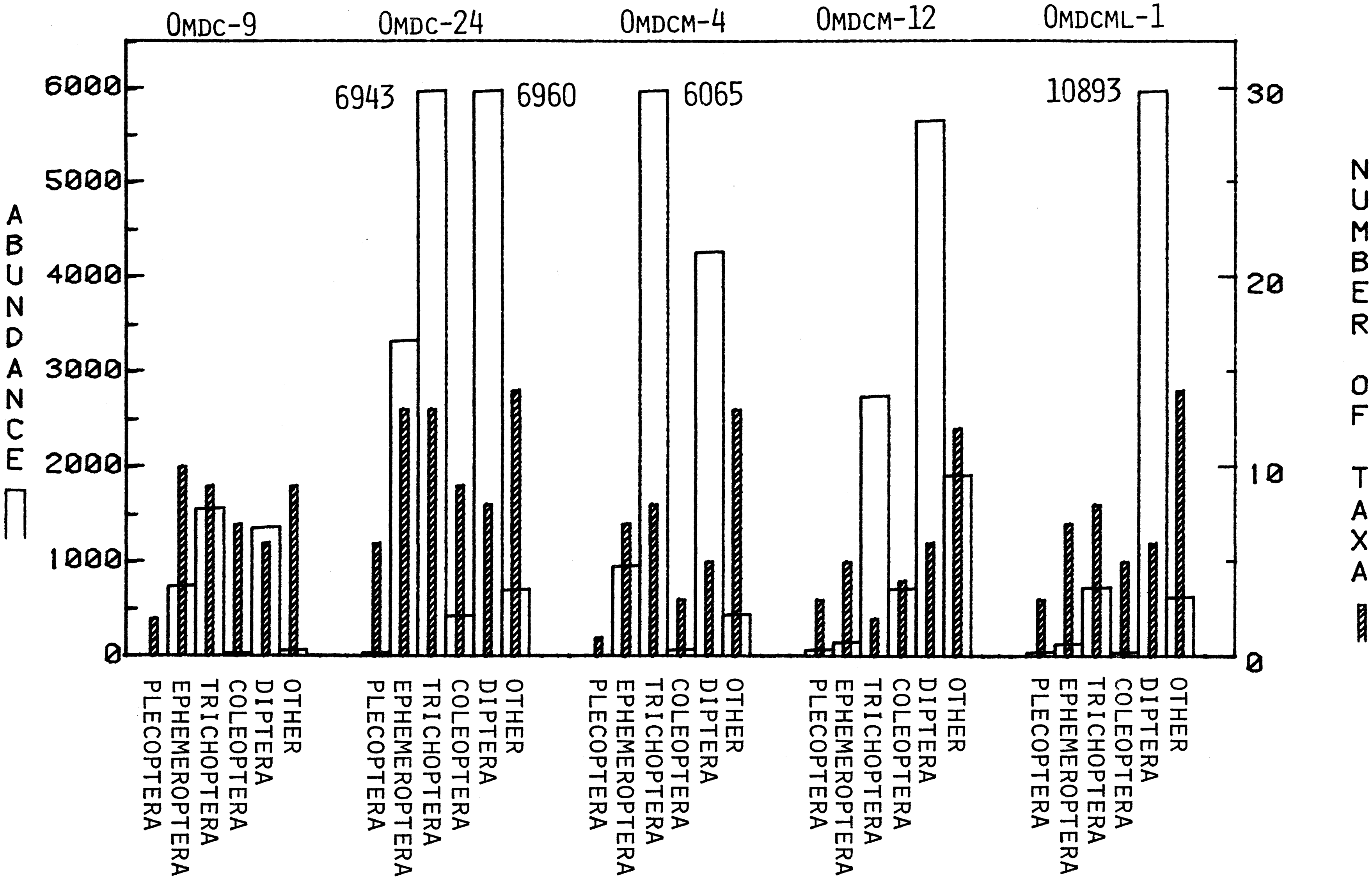


FIGURE 21. COMMUNITY STRUCTURE OF BENTHIC INVERTEBRATES BY ABUNDANCE AND TAXA FOR SAMPLES FROM THE MARAIS DES CYGNES RIVER AND MIAMI CREEK- 1975-76.

and stoneflies in the samples (Appendix Table A-11) suggests minimal impacts from these sources at the time of the survey. This abundance of sensitive taxa and the large number of all other taxa were the primary reasons for classifying the water quality at Omdc-24 unpolluted. Enrichment appears to be enhancing benthos production and has not reached the point of causing degradation. Dominant taxa at Omdc-24 were as follows:

Flies (37%)		Caddisflies (37%)		Mayflies (18%)	
Simuliidae	64%	*Cheumatopsyche* sp.	67%	*Isonychia* sp.	37%
Chironomidae	35%	*Hydropsyche cuanis*	13%	*Stenonema pulchellum*	30%
Empididae	<1%	*Potamyia flava*	13%	*Stenacron interpunctatum*	13%
		H. orris	3%	*Baetis intercalaris*	7%
		Other (4%)			
		Oligochaeta	65%		
		Sphaeriidae	10%		
		Argia moesta	7%		

The lower portion of the Marais des Cygnes River was sampled at the Bates County Route B crossing (Omdc-9), 9 miles upstream from its present confluence with the Marmaton River (Fig. 5, Table 2). This site was located in the channelized reach and is now within the flood pool of Truman Reservoir. The absence of riffles necessitated the use of artificial substrate samples (Fig. 2). Substrate at Omdc-9 was primarily clay hardpan. Water clarity varied with the flow at this site. Temperatures were moderate and periphyton growth was virtually non-existent. The surrounding land use was intensive agriculture. Non-point pollutants from agricultural practices were the only potential problems identified upstream from this reach. Point source problems

in Miami Creek, a major tributary, enter the old channel of the Marais des Cygnes River and could not influence water quality at Omdc-9 since the junction of the old channel and the Bates County Drainage Ditch is several miles below Omdc-9. A water sample collected at this site in 1973 by Kersh (1977) showed more normal values for bacteria and nutrients than were found at Omdc-24 during 1974-75 (Appendix Table A-3). Benthos standing crop was considered moderately high when compared to most other sites in the survey (235 organisms per square foot), however, was the lowest within the Marais des Cygnes River Basin (Fig. 20; Appendix Table A-11). Benthos samples were only obtained for the summer and winter seasons. Vandals removed the artificial substrates from the river during the fall and spring seasons. These missing data made water quality evaluations based on annual benthos community characteristics impossible. Seasonal (sample) characteristics for pollution sensitive taxa and diversity, however, approached and exceeded minimum criteria for unpolluted streams (Appendix Table A-11, Table 3). These characteristics and good representation of other taxa suggests that water quality in this reach is good and not greatly affected by pollution (Fig. 21). The lower invertebrate production was probably associated with the reduction of habitat by channelization. Dominant taxa in the two samples at Omdc-9 were:

Caddisflies (41%)		Flies (36%)		Mayflies (19%)	
Potamyia flava	71%	Chironomidae	87%	Stenacron interpunctatum	42%
Hydropsyche orris	15%	Simuliidae	10%	Stenonema pulchellum	24%
Cheumatopsyche sp.	6%	Empididae	1%	Tricorythodes sp.	9%

Other (2%)	
Oligochaeta	34%
Argia apicalis	22%
Corydalus cornutus	13%
Orconectes sp.	9%

The invertebrate community structure at these two mainstem sites each were similar to those at 15 other sites in the Osage River Basin (Appendix Table A-23). The specific sites, however, varied considerably. Community structure at Omdc-24 was typical of other prairie streams, with 73% of the similar sites located on prairie streams. The community at Omdc-9, however, was similar to communities at Ozark (46%) and intergrade sites (33%). Only the site on Bear Creek, a tributary to the Sac River (Fig. 4; Osb-8), had an invertebrate community similar to those at both Omdc-24 and Omdc-9. Cluster analysis also separated these two sites (Appendix Table A-24). The community at Omdc-24 was included with seven other sites. All eight sites had communities dominated by blackflies and Cheumatopsychid caddisflies. This community aligned closely with those sites downstream from Ozark Fisheries, Inc., i.e., Mill Creek (Oawm-1) and Wet Auglaize Creek (Oaw-5). The community structure at Omdc-9 on the other hand was included in the large midge-mayfly-caddisfly cluster containing many of the previously discussed mainstem Osage and minor mainstem tributary sites. The community at Omdc-9 was most closely aligned with that at O-271, the uppermost site on the prairie portion of the mainstem Osage River (Fig. 3).

These analyses suggest the following. Even though water quality throughout the Marais des Cygnes River in Missouri did not appear to be seriously affected by pollution and physical alterations at the time of this survey, the potential for degradation appears greater in the unaltered portion because of upstream enrichment. Pollution abatement and wise use of the surrounding land must continue if the Marais des Cygnes River in Missouri is to remain classified unpolluted.

Miami Creek

Miami Creek is the largest of the tributaries to the Marais des Cygnes

River lying within Missouri's boundaries. It begins in the extreme northwest corner of Bates County near Merwin, Missouri. Originally, it flowed for 36 miles before entering the Marais des Cygnes River. Channelization of the lower 12% of Miami Creek during the early 1900's moved the mouth of Miami Creek 9 miles down the original channel of the Marais des Cygnes River. This construction, known as the Miami Drainage Ditch, increased the present total length of Miami Creek to 38 miles. The channelized 4.5 miles (12%) is now located within the flood pool of Truman Reservoir causing a double burden on this stretch. The unaltered portion of Miami Creek and its watershed exhibited many of the physical and chemical characteristics found in the unchannelized reaches of the Marais des Cygnes River. Agriculture was the primary land use. The potential problems with non-point pollution existed in Miami Creek and were evident in decreased water clarity and elevated nutrient levels (Appendix Table A-3). Unchannelized reaches of Miami Creek were meandering with steep sided streambanks which were exposed to erosion. Riffle areas were stable with the substrate consisting of varying sized fragments of shale. Sampling sites on Miami Creek were set up at two locations to primarily monitor point source discharges from Butler, Missouri (Fig. 5, Table 2). These point source discharges included four small sewage treatment lagoons (average P.E.=124), quarry washings, and the discharge from the municipal lagoon serving Butler, Missouri (P.E.=7600). This last source discharged into Miami Creek via Mound Branch located between Omdcm-12 and Omdcm-4 (Table 1). The 3 miles of Mound Branch downstream from the Butler sewage treatment lagoon was considered moderately polluted during a general statewide pollution survey (Missouri Department of Conservation 1978). Invertebrate standing crop at both sites was quite high, averaging 402 organisms per square foot at Omdcm-12 and 295 at Omdcm-4 (Fig. 20, Appendix Table A-1). The density at Omdcm-12 was the highest recorded in the Marais

des Cygnes River Basin.

Benthic invertebrate community characteristics for samples collected at both sites were also quite similar (Fig. 20, Appendix Table A-11). Seasonal and annual characteristic values were consistently on the borderline between polluted and moderately polluted water quality (Table 3, Appendix Table A-11). Although the coefficient of similarity calculated for Omdcm-4 and Omdcm-12 indicated that the communities were alike (C=52), these communities were placed in two adjacent clusters (Appendix Table A-24). The community structure at Omdcm-12 was similar to that at 11 other sites in the Osage River Basin. Only 2 of these sites were not located on prairie streams (Oaw-5 and Oawm-1, Fig. 3, Appendix Table A-23). The blackfly (Family Simuliidae) - caddisfly (Cheumatopsyche sp.) community found in the upper Marais des Cygnes River (Omdc-24), Mulberry Creek (Omdcml-1), and five other sites were included in the cluster with the invertebrate community at Omdcm-12.

The community at Omdcm-4 was similar to eight other sites, half which received quantities of treated sewage effluent (Appendix Table A-23). Six of the eight sites were on prairie streams. This community, however, clustered only with that at Og-17 near the mouth of the South Grand River (Fig. 5). Both communities were characterized as a caddisfly-midge-mayfly community with very high densities in the first two types.

Dominant taxa at the two sample sites on Miami Creek are listed below and graphically depicted in Figure 21:

Omdcm-4

Caddisflies (51%)		Flies (36%)		Mayflies (8%)	
Cheumatopsyche sp.	98%	Chironomidae	90%	Baetis sp.	75%
Hydroptila sp.	1%	Simuliidae	9%	Caenis sp.	9%
Potamyia flava	<1%	Empididae	<1%	Stenacron interpunctatum	8%

Omdcm-12

Flies (50%)		Caddisflies (24%)		Other (17%)	
Simuliidae	72%	*Cheumatopsyche* sp.	99%	Oligochaeta	56%
Chironomidae	26%	*Hydropsyche cuanis*	1%	Sphaeriidae	31%
Empididae	1%			Hirudinea	6%

Beetles (6%)	
Stenelmis sp.	89%
Dubiraphia sp.	10%
Helodidae	1%

Although a few pollution sensitive and some facultative invertebrate types were collected at the two sites on Miami Creek, most of the taxa were pollution tolerant forms. For this reason and the borderline characteristic values, the water quality in Miami Creek was classified as polluted. The lack of point source discharges upstream from Omdcm-12 suggests that non-point problems associated with intensive agriculture in this region were the primary cause of these polluted conditions. Point source discharges entering from Mound Branch, upstream from Omdcm-4, did not appear to intensify the degradation. However, the change in community at this lower site may have been influenced by these discharges.

Mulberry Creek

Mulberry Creek enters the Marais des Cygnes River from the north about one mile upstream from Omdc-24 (Fig. 5). It is approximately 16 miles long. The major concern in this drainage and several other small streams in this area was the potential effects of present and past strip-mining for coal. These activities occurred in the upper 33% of the watershed (Table 1). No point sources of pollution were identified during the survey. Mulberry Creek was sampled at Omdcml-1, located about 1 mile upstream from its mouth

(Fig. 5, Table 2). The permanent riffle at this site had a substrate consisting of fragmented shale overlying sand and clay. This substrate was typical for riffles in this region and appeared similar to that found at the other sites within the Marais des Cygnes River Basin. Water clarity varied with flow and water temperature was considered moderate. The second highest invertebrate density (390 organisms per square foot) in the Marais des Cygnes River Basin was recorded in Mulberry Creek at Omdcml-1 (Fig. 20). This density, however, was variable, ranging from 22 to 927 organisms per square foot. This variability may have been influenced by discharge rates. Benthic invertebrate community characteristics on a seasonal and annual basis were consistently in the moderately polluted range (Table 3, Appendix Table A-11). The community structure of the invertebrates in Mulberry Creek clustered with those at Omdc-24, Omdcm-12 and five other sites (Appendix Table A-24). Dominant invertebrate groups in this cluster were blackflies and caddisflies including some representation of pollution sensitive forms (Fig. 21). Major taxa included:

Flies (87%)		Caddisflies (6%)		Other (5%)	
Simuliidae	89%	*Cheumatopsyche* sp.	93%	Oligochaeta	67%
Chironomidae	10%	*Hydropsyche cuanis*	4%	Sphaeriidae	21%
Empididae	<1%	*Potamyia flava*	<1%	*Lirceus* sp.	3%

Water quality in Mulberry Creek was classified moderately polluted based on the benthos data collected at Omdcml-1. No specific cause was identified during the survey. The presence of some sensitive taxa suggested a lack of acute problems. Past and present strip mine activities in the

headwater reaches did not appear to have serious degrading effects on the water quality in Mulberry Creek at this time. Non-point agricultural sources were probably the major cause of what effects were noted.

In summary, the Marais des Cygnes River and its tributaries are prairie streams and their drainage in Missouri was mostly contained within the Osage Plains Region of the Western Plains Province (Fig. 0). Benthos samples collected from the five sites on the Marais des Cygnes River (2) and two major tributaries (3) indicated that the water quality in the tributaries was poorer than in the larger mainstem reaches, even though much of the mainstem had been altered by channelization. Much of the degradation noted in the tributaries was felt to be associated with non-point sources particularly agricultural practices. Point source discharges from the Butler area contributed to the problems in Miami Creek but did not appear to intensify its already polluted status. Past and present strip mining for coal by Pittsburg and Midway Coal Company has not further aggravated the moderately polluted condition of Mulberry Creek. Other tributaries in the Marais des Cygnes River Basin, however, have had severe problems with acid mine drainage. Walnut Creek Basin, which was mined by Peabody Coal Company, is a good example. Severe degradation was documented during the 1950's from mining done in the 1940's. Water quality in the mainstem Marais des Cygnes River at both sites was considered unpolluted; however, portions showed evidence of nutrient enrichment. A minimum of about 80 miles of the streams sampled in this basin have been altered by pollution, channelization, and periodic inundation. This represents 71% of the stream mileage on the three survey streams or 19% of the total mileage of streams in the Marais des Cygnes River Basin contained in Missouri.

These five sites were primarily similar to sites on other prairie streams.

The communities on the mainstem at Omdc-9 and Omdc-24 had similarities with some Ozark and intergrade streams primarily because of the larger number of sensitive taxa found at these sites. These five sites were placed into three groups using cluster analyses. The community at Omdc-9 was included in the large cluster with many of the previously discussed minor mainstem tributaries to the Osage River. Although water quality at Omdc-24 was unpolluted, the large abundance of flies aligned it with the communities in Mulberry Creek and upper Miami Creek (Omdcm-12). The community in Miami Creek, downstream from Butler was somewhat unique and only aligned with a site on the lower South Grand River (Og-17).

In general, water quality in the Marais des Cygnes River Basin could be improved through pollution abatement and wise land use practices. However, considering the present intensive use of the watershed and past alterations, water quality could be much worse.

Marmaton - Little Osage Rivers

The Marmaton River and its major tributary, the Little Osage River, join with the Marais des Cygnes River to form the mainstem Osage River. Unlike the Marais des Cygnes River Basin, the portion of the Marmaton River Basin within Missouri is wholly contained within the Cherokee Plains Region of the Western Plains Province (Fig. 0). Since the majority of the Marmaton and Little Osage rivers are in Kansas, this discussion will deal only with the water quality in the lower reaches which are contained in Missouri. These reaches include the lower 44% (47 miles) of the mainstem Marmaton River and the lower 31 miles (35%) of the Little Osage River.

The major land use in the Cherokee Plains Region and these basins is agriculture. Wheat and soybeans are the major crops. The thinner overburden

in this region has also resulted in increased mining activities. Strip-mining for coal was more prevalent than in the Marais des Cygnes River Basin. In fact, most of western Vernon County has been affected by past or present mining activities. Channelization has not been a problem in these basins. The flood pool of Truman Reservoir, however, periodically inundates the lower reaches of the Marmaton (55%) and Little Osage (32%) rivers in Missouri.

The streams within the Marmaton and Little Osage river basins supported 52 species of fish representing 12 families (Table 4). This is quite low for a basin this size and represents the lowest diversity of fish species in the Osage River Basin. This low assemblage was equaled in the South Grand River Basin. Aquatic invertebrate communities at the six sample sites were also the least diverse of the eight Osage River Basin subdivisions (Table 5). Only 86 taxa of invertebrates were collected at the six sites including very few pollution sensitive forms (14 taxa of mayflies and stoneflies). These low numbers are associated with an overall reduction in habitat resulting from the chronic effects of non-point problems in the basin.

Marmaton River (Mainstem)

The lower 47 miles of the Marmaton River were sampled at two locations (Fig. 5). These sites were established to monitor the effects of point and non-point pollutants on the water quality in the Marmaton River. Om-24 was established upstream from most of the Missouri point and non-point pollution sources which discharge into the Marmaton River (Fig. 5, Table 2). The only potential problems identified upstream from this site in Missouri were oil drilling stations for Shell Oil Company (Table 1). No attempt was made to identify specific point and non-point sources in the 60 miles of Marmaton

River in Kansas, however, their influence on the water quality at Om-24 must be considered. Benthos were collected from a permanent riffle consisting of varying sized fragments of shale. Physical appearance of this substrate was similar to that found in the Marais des Cygnes River at Omdc-24. The size of fragments, however, tended to be much smaller at Om-24 with most fragments being gravel-sized. Land use in this reach was primarily pasture and woodland with less emphasis on rowcrops than in the Osage Plains Region. Water clarity was clear to moderately turbid depending on the amount of runoff entering the river above this site. Temperatures were moderate with slight to moderate periphyton growths on the substrate. Results of water sampling conducted by Kersh (1977) showed that bacteria and nutrient values were not abnormally elevated. Water in the Marmaton River, however, was highly mineralized based on high values for specific conductance and sulfates. This was especially true at the downstream site, Om-9 (Appendix Table A-4).

These chemical characteristics differ markedly from those found in the Marais des Cygnes River Basin (Appendix Table A-3). Benthos abundance at the two mainstem Marmaton River sites was considered moderate when compared to the previous basins but density at these two sites was the highest recorded for the six sites within this basin (Fig. 22). The highest average standing crop in the Marmaton and Little Osage river basins was found at Om-24 (169 organisms per square foot). Benthic invertebrate community characteristics at this site were also the highest of the six sites (Fig. 22). These values consistently fell within the moderately polluted range (Appendix Table A-13, Table 3) and were the basis for classifying the water quality at this site moderately polluted. A moderately diverse assemblage of pollution sensitive, facultative and tolerant forms were found at Om-24, as seen below and in

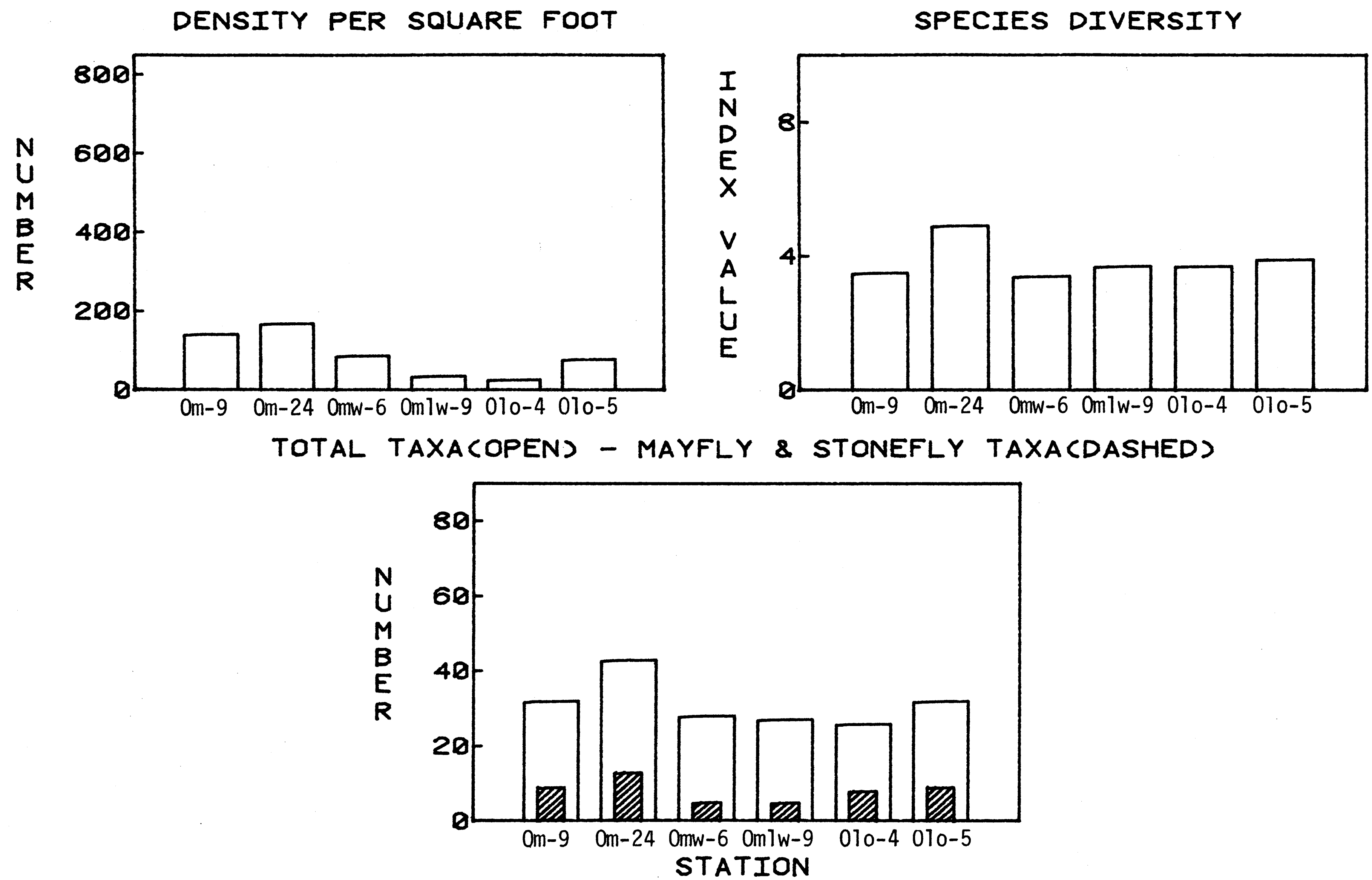


FIGURE 22. BENTHIC INVERTEBRATE COMMUNITY CHARACTERISTICS FOR SAMPLES FROM THE MARMATON AND LITTLE OSAGE RIVERS- 1975-76.

Figure 23. This suggests that point and non-point problems in the upper 56% of the basin in Kansas may be causing chronic degradation upstream from Om-24. These dominant forms at this site were:

Caddisflies (38%)		Flies (29%)		Mayflies (23%)	
Cheumatopsyche sp.	92%	Chironomidae	51%	_Baetis_ sp.	65%
Potamyia flava	3%	Simuliidae	47%	_Tricorythodes_ sp.	15%
Ochrotrichia sp.	1%	Empididae	1%	_Stenonema pulchellum_	8%
		Beetles (5%)			
		Stenelmis sp.	99%		
		Dubiraphia sp.	1%		

Benthos density and community characteristics were slightly lower at Om-9 but still fell within the moderately polluted range (Fig. 22, Appendix Table A-13, Table 3). The Marmaton River, upstream from Om-9, received discharges of treated sewage effluent from three trickling filter plants (P.E.>10,000), several small lagoons, and drainage from active and abandoned coal mine lands. The majority of the point pollutants entered the Marmaton River from tributaries such as White Branch and Dry Wood Creek (Table 1). In addition, agricultural sources of non-point pollution were also present. A 1978 pollution survey considered 2.5 miles of White Branch moderately polluted from the Nevada sewage treatment facility (Missouri Department of Conservation 1978). The riffle sampled at Om-9 was located approximately 5 miles downstream from the confluence of the Marmaton River and Little Dry Wood Creek (Fig. 5, Table 2). Substrate at this site was comparable to that found upstream at Om-24. The particle size distribution had shifted from predominantly gravel at Om-24 to an even distribution of rubble, gravel and sand sized shale fragments at Om-9. Chemical sampling done at this site by Kersh (1977) during

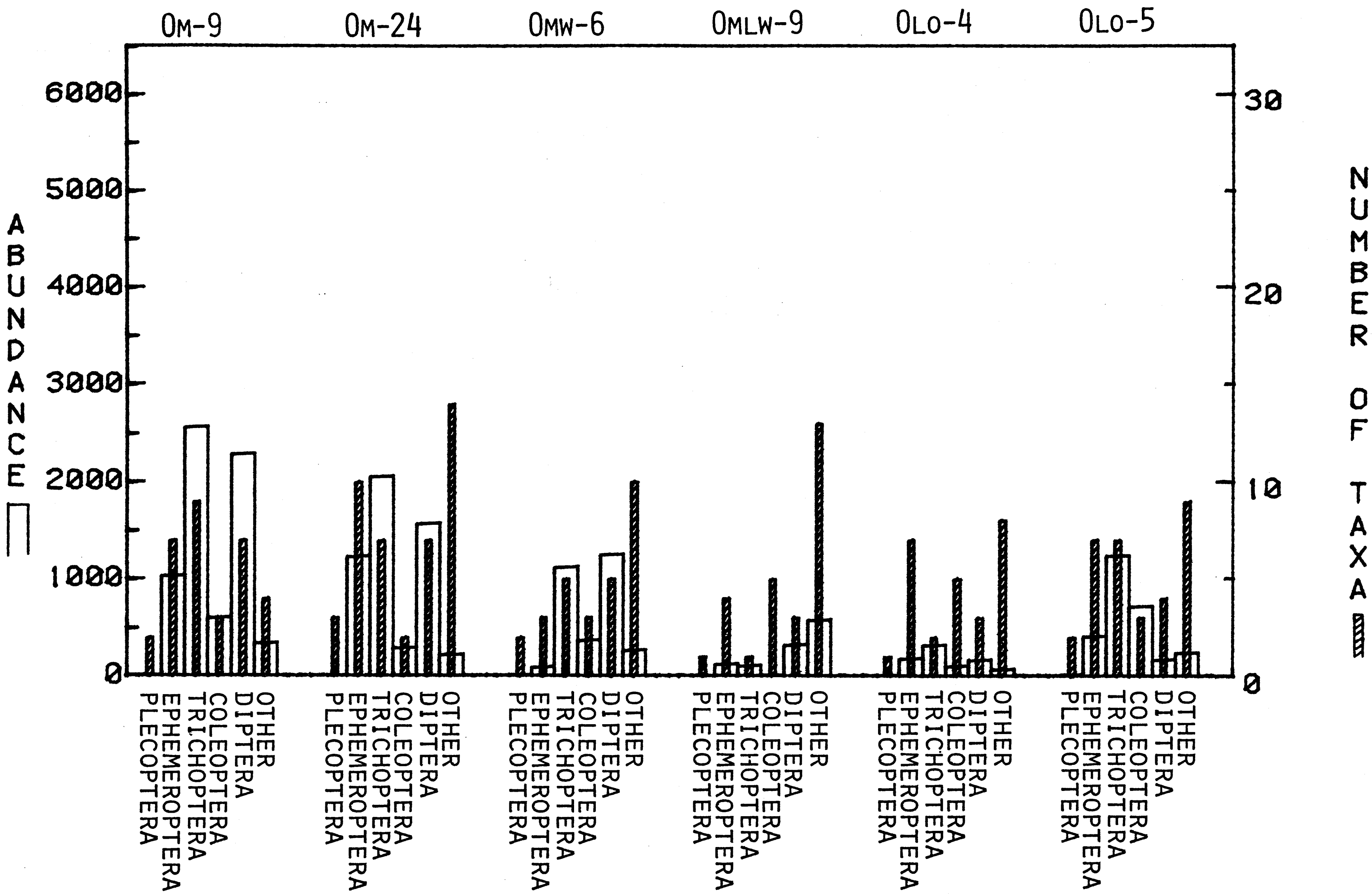


FIGURE 23. COMMUNITY STRUCTURE OF BENTHIC INVERTEBRATES BY ABUNDANCE AND TAXA FOR SAMPLES FROM THE MARMATON AND LITTLE OSAGE RIVERS- 1975-76.

1973-75 indicated that the range of most constituents were similar to those found at Om-24, however, average turbidity and sulfate levels had increased significantly. These parameters averaged four and eight times higher at Om-9 than at Om-24 (Appendix Table A-4). The major cause for these increases was felt to be non-point in origin, primarily strip mine runoff entering from tributaries in southern Vernon and northern Barton counties. Based on benthic invertebrate community characteristics, point sources entering upstream from Om-9 did not significantly degrade the water quality in the Marmaton River beyond the moderately polluted conditions found at Om-24. Invertebrate community structure at these two sites was almost identical (Fig. 23). This similarity (C=70) further supports the lack of increased degradation in the lower reaches of the Marmaton River (Fig. 23). As stated previously, the moderately polluted conditions in the Marmaton River were from chronic problems in the basin mostly associated with non-point sources.

The invertebrate communities in the Marmaton River at Om-9 and Om-24 were in the same cluster (Appendix Table A-24). This cluster was characterized by medium density populations of Hydropsychid caddisflies, flies (midges and blackflies), mayflies, and beetles.

Caddisflies (38%)		Flies (34%)		Mayflies (15%)	
Cheumatopsyche sp.	58%	Chironomidae	59%	*Tricorythodes* sp.	47%
Potamyia flava	30%	Simuliidae	35%	*Stenonema pulchellum*	31%
Hydropsyche cuanis	6%	Empididae	<1%	*Stenacron interpunctatum*	7%

Beetles (9%)	
Stenelmis sp.	99%
Dubiraphia sp.	<1%
Dryopidae	<1%

The ten sites included in this cluster were located on prairie and intergrade streams.

The communities at Om-9 and Om-24 were similar to communities at 29 and 18 other sites, respectively (Appendix Table A-23). Similarities with the community at Om-24 were located primarily on prairie stream (50%), followed by Ozark (27%) and intergrade streams (22%). The benthos community at Om-9, although indicative of moderately polluted water quality was quite cosmopolitan in structure. The dispersal of similarities for this community was 55% Ozark, 31% prairie, and 13% intergrade streams.

Dry Wood Creek

Dry Wood Creek and some of its tributaries have had documented pollution problems caused by acid drainage from abandoned deep and surface coal mines. These problems date back as far as 1949. Since that time, three fish kills resulting from acid runoff have also been documented. These problems, coupled with sewage lagoon effluent from Liberal, Missouri (P.E.=1650), the effects of present coal mining, occasional spills related to oil drilling and other non-point sources have degraded the water quality in Dry Wood Creek (Table 1). Fourteen miles of Dry Wood Creek in Barton County were classified moderately polluted from acid mine drainage in 1978 (Missouri Department of Conservation 1978). This report also noted additional degradation in Vernon County.

Dry Wood Creek begins in west-central Barton County and flows north for 41 miles before entering the Marmaton River near Deerfield, Missouri. It's basin is completely contained within the Cherokee Plains Region (Fig. 0). Land use patterns in this basin are typical for this geographic region. Benthos samples were collected with a riffle net at the Vernon County Route KK crossing (Omw-6) indicated in Figure 5 (Table 2). Physical habitat in this reach

was similar to that found at the Marmaton River sites and most other prairie streams. The riffle substrate consisted of shale fragments overlying clay hardpan. The initial sample (Summer 1975) was collected from an unstable riffle consisting of very fine shale particles over clay. Subsequent samples were collected from the next riffle downstream. Substrate at this riffle was stable and consisted of varied sized shale fragments which are typically found in most prairie streams of the Western Plains Province. Water clarity varied from clear to moderately turbid depending on the amount of runoff. Water temperatures and periphyton growths were moderate. Major taxa collected at Omw-6 during 1975-76 were in the following groups:

Flies (40%)		Caddisflies (35%)		Beetles (12%)	
Chironomidae	87%	*Cheumatopsyche* sp.	>99%	*Stenelmis* sp.	98%
Simuliidae	11%			*Dubiraphia* sp.	2%
Empididae	<1%				

Other (8%)	
Oligochaeta	54%
Sphaeriidae	37%
Corydalus cornutus	4%

Average sample density of invertebrates at Omw-6 was considered moderately low (87 organisms per square foot) for this prairie region and the Osage River Basin as a whole. Benthic invertebrate community characteristics consistently fell within the polluted range (Fig. 22, Appendix Table A-13, Table 3), however, a few facultative and pollution sensitive forms were collected. The pollution problems in most of Dry Wood Creek were primarily from a combi-

nation of non-point sources. They have affected the water quality in Dry Wood Creek over many years. The water quality in the portion of Dry Wood Creek upstream from Omw-6 was classified as polluted. Similar conditions are suspected throughout most of the Dry Wood Creek Basin. The presence of low numbers of a few sensitive taxa indicated that the problems were chronic rather than acute in nature.

The invertebrate community at Omw-6 had the same structure as the mainstem Marmaton River sites but a much lower abundance (Fig. 23). Structurally, this community was similar to those at 25 other sites within the Osage River Basin (Appendix Table A-23). About half of these similar sites were on Ozark streams and the remainder were equally divided between prairie and intergrade streams. This community clustered with the communities on the mainstem Marmaton River and seven other prairie and intergrade streams (Appendix Table A-24). The streams in this cluster were characterized by moderate to high density populations of midge, caddisfly, mayfly, and beetle larva.

Little Dry Wood Creek

Little Dry Wood Creek begins in central Barton County near Lamar and flows north for 44 miles before entering the Marmaton River just west of Nevada, Missouri (Fig. 5). Invertebrates were collected from a riffle located about 9 miles above it's confluence with the Marmaton River at Omlw-9 (Fig. 5, Table 2). The substrate consisted of varying sized fragments of shale with fine sizes predominating, resulting in an unstable riffle. The major land use in the upper watershed is rowcrop agriculture with wheat and soybeans being the primary crops. Very little, if any, coal has been mined in this basin. Discharges of treated sewage effluent from a subdivision (P.E.=240) and one of the trickling filter plants serving Nevada (P.E.=4000)

enter Little Dry Wood Creek downstream from Omlw-9 (Table 1). The 1978 pollution survey considered the lower 3 miles of Little Dry Wood degraded by these discharges (Missouri Department of Conservation 1978). Water clarity was generally turbid with moderate temperatures and only slight growths of periphyton on the substrate. Invertebrate abundance in samples was low, averaging 36 organisms per square foot (Fig. 22, Appendix Table A-13). Benthic invertebrate community characteristic values for these samples were also low, closely paralleling those found in Dry Wood Creek (Fig. 22). The community structure, however, was quite different (Fig. 23). These facts coupled with the poor representation of pollution sensitive taxa in Little Dry Wood Creek were the basis for classifying the water quality above Omlw-9 as polluted. Non-point pollutants, primarily sediment from the erosion of agricultural lands was considered the major cause of the degradation.

The community at Omlw-9 was similar to those at four other sites (Appendix Table A-23). All sites were characterized by having low densities, poor habitat, and serious non-point pollution problems. These five sites were also placed in the same cluster (Appendix Table A-24). The communities in this cluster were characterized by low density midge-aquatic earthworms (Class Oligochaeta)-fingernail clam (Family Sphaeriidae)-mayfly populations. The presence of a few sensitive forms (mayflies) indicates that the problems in Little Dry Wood Creek and at the other four sites are chronic in nature. The dominant taxa collected at Omlw-9 were:

Other (50%)		Flies (28%)		Mayflies (11%)	
Oligochaeta	84%	Chironomidae	94%	*Caenis* sp.	47%
Sphaeriidae	6%	*Bezzia/ Probezzia*, ...,	5%	*Stenacron interpunctatum*	34%
Corixidae	3%	*Anopheles* sp.	1%	*Stenonema pulchellum*	18%

Little Osage River

The Little Osage River is the major tributary to the Marmaton River. It enters from the west, about 13 miles upstream from the confluence of the Marmaton and Marais des Cygnes rivers (Fig. 5). The Little Osage River originates in east-central Kansas and flows for 87 miles before reaching the Marmaton River. The lower 31 miles (35%) of the mainstem are in Missouri. The drainage in this reach is divided across the Osage and Cherokee Plains regions (Fig. 0). Land surrounding this portion of the Little Osage River is intensively used for agriculture. Portions of the watershed have also been strip-mined for coal in the past. Much of this acreage has been poorly reclaimed. Exploration for oil by Nichols Oil Company has also become an important activity in recent years. Dumping and discharges of wastes from Richhill Rendering Company near Metz, Missouri was the only point pollution problem identified within this reach during the survey (Table 1). Department of Conservation records document problems with rendering wastes being discharged in the Little Osage River as far back as 1956.

The Little Osage River was sampled at two sites located upstream (Olo-5) and downstream (Olo-4) from this rendering company (Fig. 5, Table 2). Water samples collected by Kerch (1977) during 1975 showed very similar water chemistry conditions in the Little Osage River and in the Marmaton River at Om-24 (Appendix Table A-4). Physically, water at the two sites on the Little Osage River was also quite similar. Clarity was moderately turbid and temperatures were moderate. Both sites supported only slight amounts of periphyton throughout most of the year. Substrate at the two sites, however, was quite different. Large shale and sandstone fragments overlying sand comprised the substrate at Olo-5, whereas, large angular shale over

clay was common at Olo-4. Samples at both sites were collected at permanent riffle sites with a riffle net.

Invertebrate abundance at Olo-4 was the lowest in the Marmaton-Little Osage river basin and third lowest in the Osage River Basin. Benthos samples averaged 27 organisms per square foot. Density at Olo-5 was 78 organisms per square foot (Fig. 22, Appendix Table A-13). Benthic invertebrate community characteristics were comparable to those at the sites on the Marmaton River and generally were borderline between the polluted and moderately polluted range (Appendix Table A-13, Table 3). The communities at these two sites were not highly diverse but did have some pollution sensitive taxa represented in samples throughout the year. Invertebrate community structure, however, between the two sites was quite different (Fig. 23). The community at Olo-5 was similar to eight other communities in the Osage River Basin (Appendix Table A-23). These sites were on prairie or intergrade streams except Opl-63 on Lindley Creek (Fig. 4). The benthos community at Olo-4 was similar to only three other sites. The community at Olo-5 clustered with nine other sites on prairie and intergrade streams (Appendix Table A-24). This cluster contained many of the sites in the Marmaton River Basin including Om-9, Om-24 and Omw-6. Site Olo-4 clustered with two other sites, Osc-1 on Cedar Creek in the Sac River Basin (Fig. 4) and Op-13 near the mouth of the Pomme de Terre River. This cluster was characterized by a community containing large numbers of Cheumatopsychid caddisflies, Stenonema mayflies, and midges. Dominant taxa at the two sites were as follows:

Olo-4

Caddisflies (37%)		Mayflies (22%)		Flies (19%)	
Cheumatopsyche sp.	96%	Stenacron interpunctatum	42%	Chironomidae	72%
Hydropsyche cuanis	4%	Baetis sp.	19%	Simuliidae	25%
		Stenonema pulchellum	17%	Empididae	3%

Beetles (12%)	
Stenelmis sp.	96%

Olo-5

Caddisflies (44%)		Beetles (25%)		Mayflies (15%)	
Cheumatopsyche sp.	97%	Stenelmis sp.	>99%	Baetis sp.	49%
Hydropsyche cuanis	2%	Optioservus sandersoni	<1%	Stenocron interpunctatum	17%
Ceraclea alagmus	<1%	Macronychus sp.	<1%	Stenonema pulchellum	16%
				Heptagenia sp.	10%

Other (9%)	
Oligochaeta	85%
Sphaeriidae	8%
Corydalus cornutus	2%
Hirudinea	2%

Based on the biological information collected from the Little Osage River, water quality in the lower reaches was classified moderately polluted. Although characteristic values at Olo-4 were slightly lower than those at Olo-5, degradation appeared uniform throughout the lower 5 miles. The 1978 pollution survey classified the lower 4 miles of the Little Osage River moderately polluted (Missouri Department of Conservation 1978). The primary source of degradation in the Little Osage River was felt to be from non-point

erosion and sedimentation of agricultural lands. It was not possible to attribute the slight decrease in benthic invertebrate community characteristics at Olo-4 to rendering wastes but this discharge to the river is considered a contributing factor. Better soil conservation practices would help to improve the conditions in this basin.

The completion of Truman Reservoir placed 32% of the Missouri portion of the Little Osage River within its floodpool elevation. This inclusion places additional stress on the lower 10 miles.

In summary, water quality in the Marmaton-Little Osage river basin has been degraded over the years primarily by poor land use practices. Water quality at four of the six sites sampled was classified moderately polluted. Water quality at the other two sites (Omlw-9 and Omw-6) was classified polluted. Chronic non-point problems associated with intensive agriculture were the primary cause of the decline. This was followed by runoff from abandoned and active strip-mined lands and discharges of domestic sewage. In total, at least 78.5 miles of stream in the Marmaton River within Missouri were affected by pollution. This represents 10% of the total stream mileage, order 2 or greater, within this basin. Most of the above detectable affects were on the mainstems of the four survey streams. Polluted or moderately polluted conditions on these mainstem reaches accounted for 62 miles or 38% of their total mileage in Missouri. Periodic inundation associated with the flood pool of Truman Reservoir placed additional stress on the lower Little Osage (10 miles) and Marmaton rivers (26 miles).

The benthos in the Marmaton-Little Osage river basin were present in much lower densities than in the Marais des Cygnes River Basin. Densities ranged from 27 organisms per square foot in the Little Osage River to 169 in the upper Missouri reach of the mainstem Marmaton River. The lowest

density (235 organisms per square foot) in the Marais des Cygnes River was found in the mainstem, channelized portion (Omdc-9). Benthic invertebrate community characteristics were generally quite uniform and fell within the upper polluted and lower moderately polluted range of water quality (Table 3). The community structure of the invertebrates in these prairie streams was also quite homogeneous throughout the basin. Four of the six sites aligned in the same cluster which was dominated by caddisflies, flies, mayflies and beetles. The remaining communities were more isolated.

These basic similarities suggest that the water quality degradation observed in this basin have resulted from long-term, chronic problems. Intensive use of the land for agriculture is probably the major cause. Mining, inundation and point source discharges locally aggravate these problems. Reclamation, proper land use and abatement would help to relieve the stress in these basins.

South Grand River

Most of the South Grand River and its tributaries are considered prairie streams since the drainage basin is contained primarily within the Western Plains Province (Fig. 0). Only the lower 39 miles of the mainstem flow along the Osage-Gasconade Hills Region of the Ozark Highland Province. The South Grand River begins in northwest Cass County near Belton, Missouri and originally flowed for 153 miles before entering the Osage River near Warsaw (Fig. 5). Channelization has shortened the mainstem by 20%, leaving about 130 miles remaining. According to Stout and Hoffman (1973), this basin drains about 2000 square miles at its mouth, making it the second largest basin within the Osage River Basin.

Water quality in the South Grand River Basin was a function of land use

and these uses were controlled to some degree by the geographical province. Portions of the South Grand River and its tributaries upstream from the mouth of Big Creek (Fig. 5) were in the Osage Plains Region and influenced by non-point problems associated with agricultural practices. Effects from strip-mining for coal were evident in the reach draining the Cherokee Plains Region. Tributaries affected by drainage from unreclaimed strip mine land were primarily in the Tebo Creek Basin.

Intensive mining was also present in the Deepwater Creek Watershed, however, the effects were less obvious. Finally, the completion of Truman Reservoir permanently inundated the lower 48% of the South Grand River mainstem and most of mainstem Tebo and Deepwater creeks. Four mainstem sample sites were permanently covered (Og-17, Og-49, Ogd-7, Ogt-18) and six others are now subject to periodic flooding (Og-80, Ogdb-5, Ogb-5, Ogtw-3, Ogtm-3). Point source discharges were present throughout the basin. Their effects were usually quite localized or masked by non-point problems.

Biologically, the South Grand River Basin supported 52 species of fish representing 12 families (Table 4). This basin equalled with the Marmaton-Little Osage River Basin for the lowest fish diversity in the Osage River Drainage. The South Grand River was one of the major spawning tributaries for the population of paddlefish inhabiting the Osage River. Inundation by Truman Reservoir has eliminated most of the known spawning areas of this important gamefish and has threatened their future survival (Russell, Graham, Carlson and Hamilton 1980, Pflieger 1971). Overall, the benthic invertebrate populations in this basin were more diverse than the previously discussed prairie stream basins. A total of 132 taxa were collected at the 14 sample sites (Table 5). Although this total is higher than previous basins, the number of pollution sensitive mayfly and stonefly taxa was low. Only 22 taxa

(seventh of the eight subdivisions) were collected during the survey. This is one indication of the degrading effects of chronic non-point problems on the water quality in this basin. Inundation in 1978 has altered 19% of all the stream mileage in the basin which could ultimately affect the benthos by reducing the variety of habitat types which were present during the survey.

South Grand River (Mainstem) and East Branch of South Grand River

The uppermost sampling site (Og-100) on the mainstem South Grand River was located at the Highway 2 crossing, west of Harrisonville, Missouri (Fig. 5, Table 2). Invertebrate samples were collected using artificial substrate samplers shown in Figure 2. Flow in this reach was sluggish and substrate consisted primarily of mud and silt. Stream banks were lightly vegetated and surrounding land use was agricultural. Water clarity was consistently turbid and temperatures moderate. No excessive periphyton growths were noted.

Backwash from the drinking water treatment plant and the discharge from a small sewage treatment lagoon at Raymore, Missouri plus treated sewage effluent from Belton, Missouri (P.E.=5700) were the only point discharges of pollution identified during this survey (Table 1). These discharges enter over 15 miles upstream from Og-100.

Water quality at Og-100 was classified as moderately polluted. Benthos density was moderate in this reach, averaging 177 organisms per square foot. Community characteristic values generally fall within this classification except for the number of mayfly and stonefly taxa (Fig. 24, Table 3, Appendix Table A-15). Values for this characteristic fell consistently in the polluted range. Gradual habitat degradation from non-point erosion and and sedimentation over many years has influenced the benthic invertebrate

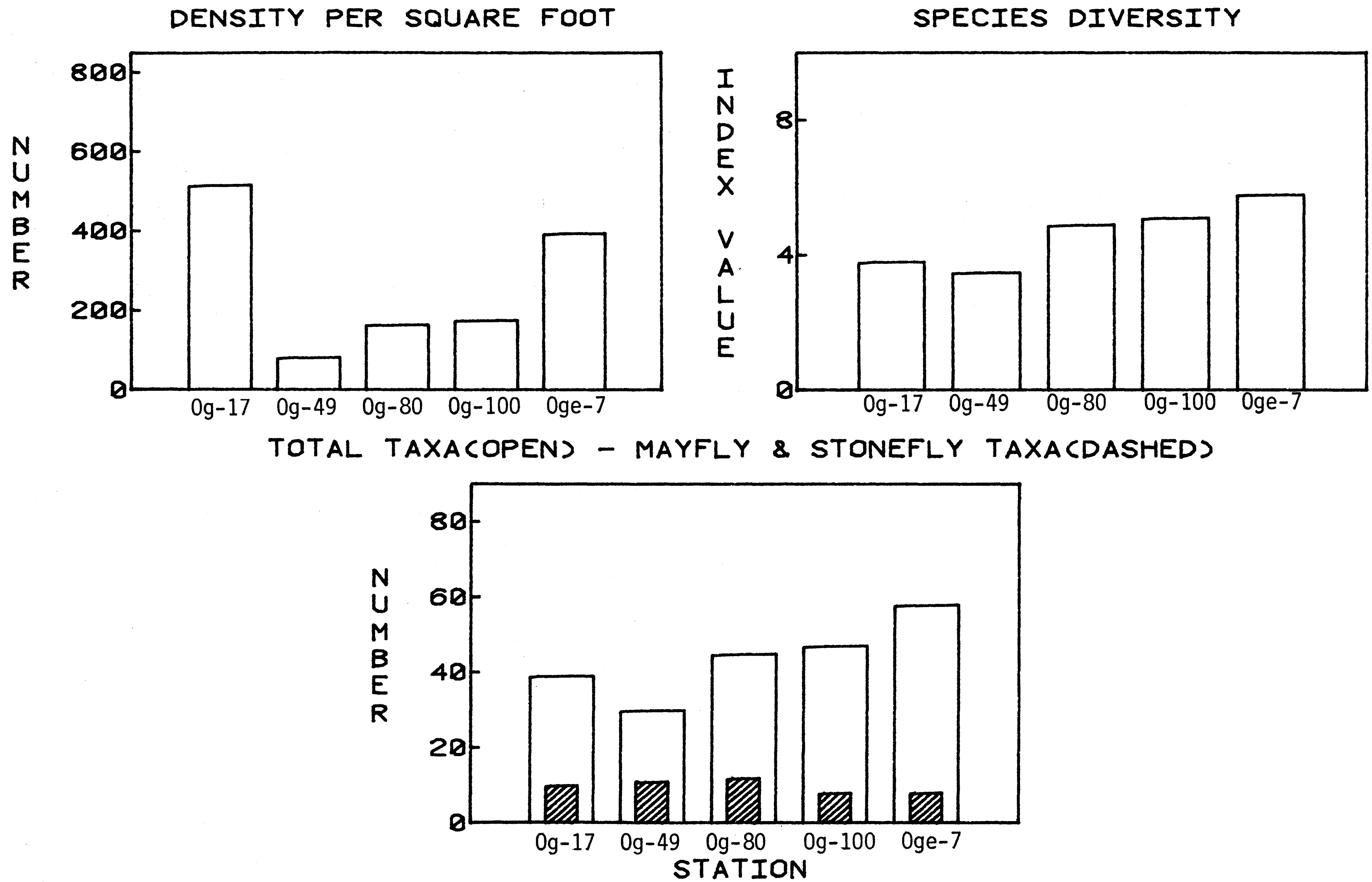


FIGURE 24. BENTHIC INVERTEBRATE COMMUNITY CHARACTERISTICS FOR SAMPLES FROM THE MAINSTEM SOUTH GRAND RIVER AND EAST BRANCH- 1975-76.

community structure in this portion of the South Grand River. Sluggish flow and silty substrate has eliminated sensitive stonefly taxa which were found in limited numbers at other mainstem sites (Fig. 25). This environment, however, did support some mayfly taxa which are tolerant of silty substrates and fair populations of other facultative forms. Taxa which did quite well were aquatic earthworms and midges. These were the dominant groups collected at Og-100:

Flies (52%)		Other (30%)		Mayflies (12%)	
Chironomidae	94%	Oligochaeta	52%	*Stenacron interpunctatum*	76%
Bezzia/*Probezzia*, ...,	5%	*Argia tibialis*/*apicalis*	16%	*Caenis* sp.	19%
Stratiomyidae	<1%	*Hyalella azteca*	14%	*Hexagenia limbata*	3%

Point source discharges identified upstream from Og-100 were considered to have some localized effects but did not contribute greatly to the long-term degradation which was noted during this survey.

The benthos community at Og-100 was similar to communities at 16 other sites in the Osage River Basin (Appendix Table A-23). The majority of these sites (75%) were on prairie and intergrade streams. The community at Og-100 was in the cluster with ten other sites dominated by aquatic earthworms and midges (Appendix Table A-24). Several of these sites were affected by different activities - acid mine drainage, erosion and sedimentation, and treated sewage effluent. However, the resulting effect on the community as a whole was the same.

The East Branch of the South Grand River joins the mainstem north of

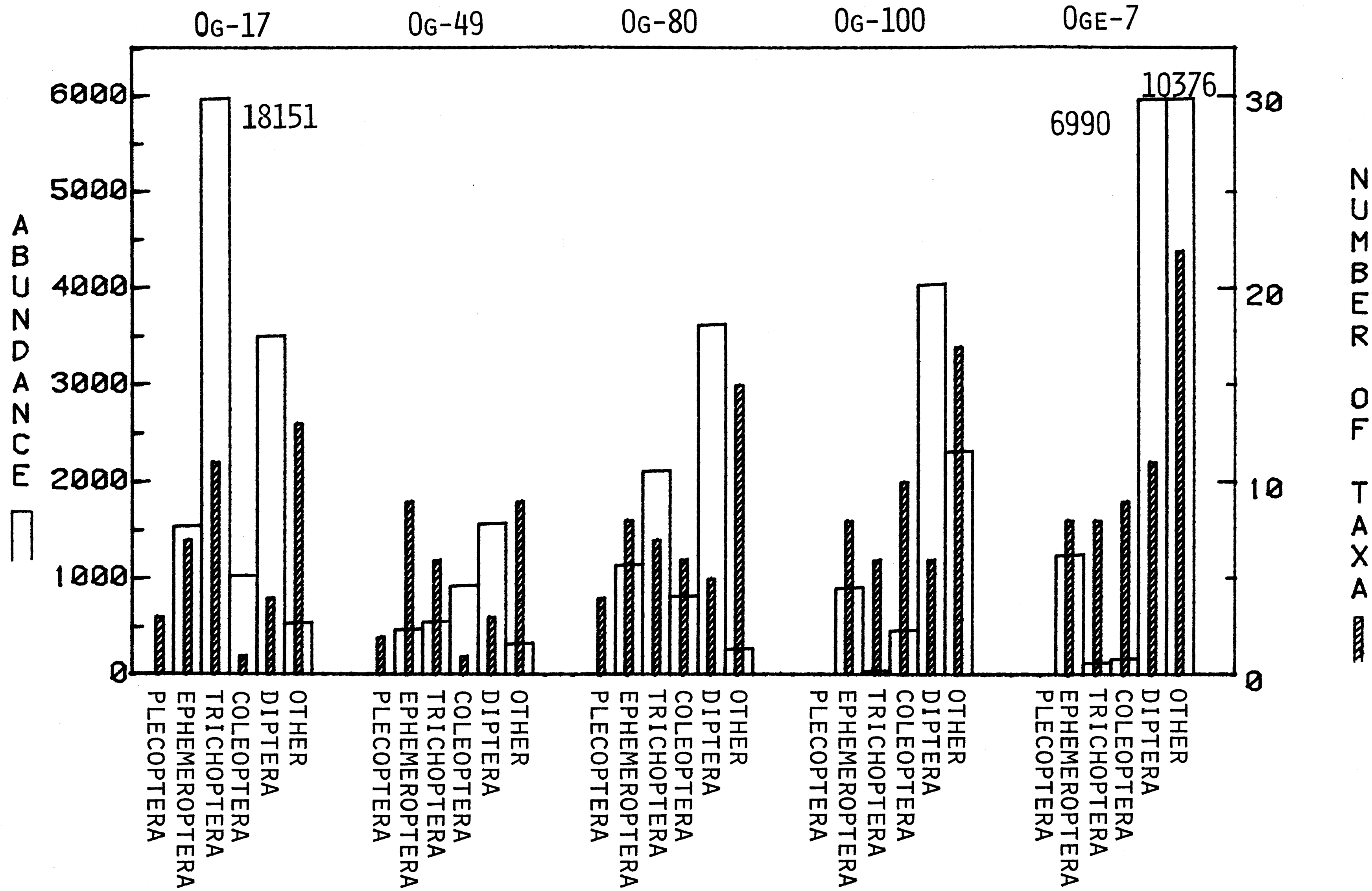


FIGURE 25. COMMUNITY STRUCTURE OF BENTHIC INVERTEBRATES BY ABUNDANCE AND TAXA FOR SAMPLES FROM THE MAINSTEM SOUTH GRAND RIVER AND EAST BRANCH- 1975-76.

Archie, Missouri, downstream from Og-100. East Branch begins in north-central Cass County and flows south for about 28 miles before reaching the South Grand River. At their confluence, these two streams are comparable in size. Substrate consisted of mud and silt overlying bedrock. Water clarity was much less turbid than at Og-100 suggesting less influence from non-point problems. Surrounding land use was primarily agricultural, but much more vegetation covered the stream banks than at Og-100. Point source discharges upstream from Oge-7 (Fig. 5) were comparable to those identified in the South Grand River (Og-100). Drinking water treatment plant backwash and treated sewage effluent from several sources (Total P.E.=736) enter East Branch from Peculiar, Missouri, about 17 miles upstream (Table 1). Treated sewage effluent from Harrisonville, Missouri (P.E.=10,000) entered East Branch via Muddy Creek (Table 1) about 5 miles upstream from Oge-7.

Benthos samples were collected at Oge-7 with artificial substrates since the substrate in East Branch was silty and the flow was relatively sluggish. The benthic invertebrate community characteristics from these samples were the highest in the South Grand River Basin except for mayfly and stonefly taxa (Fig. 24, Appendix Table A-15). Some values of total taxa and seasonal diversity index exceeded minimum criteria for unpolluted streams (Table 3). Invertebrate density was considered high, averaging 394 organisms per square foot. Comparing these characteristics to other prairie streams, the values at Oge-7 were exceeded only by those at Omdc-24 on the Marais des Cygnes River (Appendix Tables A-11, A-13, and A-15). Water quality in East Branch approached unpolluted status but the absence of stoneflies and reduced number of sensitive mayflies suggest some degrading influences. The influences were primarily from chronic non-point problems stemming from poor land use practices. Effects from point source discharges

were again felt to be localized. The 1978 pollution survey classified 2 miles of Muddy Creek moderately polluted by the discharges from the Harrisonville sewage treatment plant (Missouri Department of Conservation 1978). The overall degrading effects of the pollution in this watershed were considered less than those observed in the South Grand River at Og-100.

The invertebrate community in East Branch was aligned in the cluster with Og-100 and the other nine sites with Oligochaete-midge dominant communities (Appendix Table A-24). Although community structure appears different between Oge-7 and Og-100 (Fig. 25), the similarity coefficient comparing them was high (Appendix Table A-16) and the dominant taxa in samples were virtually unchanged:

Other (55%)		Flies (37%)		Mayflies (7%)	
Oligochaeta	84%	Chironomidae	98%	*Stenacron interpunctatum*	87%
Hyalella azetca	8%	*Bezzia/ Probezzia*, ...,	<1%	*Caenis* sp.	12%
Sphaeriidae	6%	Simuliidae	<1%	*Callibaetis* sp.	<1%

Site Og-80 on the South Grand River was located in a channelized portion near Dayton, Missouri (Fig. 5, Table 2). This site was located just upstream from the upper flood pool limits of Truman Reservoir. Geographically, this portion was still within the Osage Plains Region and intensive agriculture was the major land use. Point source discharges identified upstream from Og-80 during the survey consisted of periodic backwash from the drinking water treatment plants serving Archie, Cleveland, Freeman, and Harrisonville; four small sewage treatment lagoons (total P.E.=500); and the sewage lagoon serving Archie, Missouri (P.E.=660). Most of these point sources discharged into

tributaries and did not enter the South Grand River directly (Table 1). Flow in this portion was not as sluggish as at upstream sites.

Samples were collected from a stable riffle. Substrate in this riffle consisted of finer sized shale fragments overlying a clay bottom. Water clarity was comparable to that at Og-100 and moderate growths of periphyton were noted on the riffle substrate. Chemically, the water in the South Grand River at Og-80 appeared to be moderately hard, not abnormally high in nutrients or bacteria, and quite consistent with samples collected throughout the mainstem (Appendix Table A-5).

All categories of benthic invertebrate community characteristics were virtually identical to those from samples collected at Og-100 (Fig. 24, Appendix Table A-15). The only variation noted was that a few more sensitive mayfly and stonefly taxa were consistently present at Og-80. Fewer non-point problems and improved substrate may have been partially responsible for this slight increase in sensitive fauna over those found at Og-100. Although characteristic values were similar, the community structure was quite different at Og-80. This difference was especially noted by the presence of stoneflies (Family Plecoptera) and the increase in caddisfly (Family Trichoptera) abundance (Fig. 25).

The benthos community at Og-80 was similar to those at 26 other sites in the Osage River Basin which makes this community quite cosmopolitan. Of these 26 sites, 44% were considered Ozark streams, 38% were prairie streams and 18% were intergrade. Highest similarities were with sites located within the Marmaton-Little Osage river basin (Appendix Table A-23). The community at Og-80 clustered with nine other prairie and intergrade sites (Appendix Table A-24). These sites all had medium to high density communities dominated by caddisflies, midges, mayflies and beetles.

Dominant taxa at Og-80 were:

Flies (45%)		Caddisflies (26%)		Mayflies (14%)	
Simuliidae	62%	Cheumatopsyche sp.	88%	Tricorythodes sp.	47%
Chironomidae	37%	Potamyia flava	10%	Stenonema pulchellum	18%
Empididae	<1%	Hydropsyche cuanis	1%	Baetis sp.	14%
				Heptagenia sp.	8%
		Beetles (10%)			
		Stenelmis sp.	>99%		

These data indicate a slight improvement in the physical habitat at Og-80 over the more sluggish flow and silty substrate at Og-100. The effects of non-point problems may have lessened since sedimentation appeared less severe and water clarity had improved slightly. Point source problems were localized in their effects. Although conditions appeared to improve slightly, community characteristic values still fell within the moderately polluted zone (Table 3).

Water quality in the South Grand River at Og-80 was considered to be moderately polluted primarily by non-point sources. The completion of Truman Reservoir in 1978 should not cause problems at Og-80 since maximum flood pool elevation is 3 miles downstream.

The next site (Og-49) was located on the mainstem South Grand River, just southwest of Clinton, Missouri (Fig. 5, Table 2). In 1975-76, this site was upstream from the point source discharges from Clinton. This portion of the river was also unchannelized. Presently, Og-49 is permanently inundated. During the survey, two small lagoons and the sewage treatment facility at Urich, Missouri discharged into the river, upstream from Og-49

(Table 1). Geographically, this reach was located within the Cherokee Plains Region, and was downstream from the mouth of Big Creek. Erosion and sedimentation from agricultural croplands were still prevalent in this reach. In addition, areas stripmined for coal were also present at various locations upstream from Og-49. Some areas have been properly reclaimed while others have not. Physical habitat at Og-49 did not appear different from that at Og-80. Substrate consisted of angular shale fragments overlying hard clay and sand. The riffle was considered stable and adequate for good benthos production. Water clarity was moderately turbid, however, varied with stream flow. In general, chemical characteristics in water samples from Og-49 were comparable to those at Og-80 (Appendix Table A-5).

Benthic invertebrate community characteristic values were generally lower than the values at the other mainstem sites (Fig. 24, Appendix Table A-15). Density was especially low, averaging 81 organisms per square foot. This was the third lowest density recorded in the entire South Grand River Basin. Even though abundance was low, an increasing proportion of sensitive and facultative taxa were collected, as seen by the dominant taxa in the samples:

Flies (40%)		Beetles (24%)		Caddisflies (14%)	
Simuliidae	60%	*Stenelmis* sp.	100%	*Cheumatopsyche* sp.	86%
Chironomidae	39%			*Agraylea* sp.	6%
Empididae	1%			*Potamyia flava*	6%

Mayflies (12%)	
Stenonema pulchellum	38%
Baetis sp.	29%
Tricorythodes sp.	13%

Although, many of the characteristics bordered polluted water quality conditions (Table 3), the increasing number of sensitive forms was the primary basis for classifying the water quality at Og-49 as moderately polluted. Once again, the primary degrading force was non-point in nature. The community at Og-49 was similar to ten other sites in the Osage River Basin (Appendix Table A-23). These similarities were primarily with sites in the Marmaton and Sac river basins, however, the community at Og-80 had the highest coefficient with Og-49 (C=60). The benthos community at Og-49 was also placed in the cluster which contained Og-80 and many of the Marmaton River sites (Appendix Table A-24). Common invertebrate groups within this cluster were caddisflies, midges, mayflies and beetles.

The mainstem South Grand River was sampled near its mouth at Og-17 (Fig. 5, Table 2). This reach of the South Grand River was geographically located on the boundary between the Western Plains and the Ozark Highland provinces (Fig. 0). Habitat has become more intergrade in nature and the substrate appeared quite suited for invertebrate production. The varying sized and shaped shale fragments compacted into a very stable riffle. Chemically, however, the water at Og-17 did not vary appreciably from that at upstream sites (Appendix Table A-5). Water clarity was moderately turbid depending on flow and nutrients were not considered excessive. Periphyton growths were also not excessive. The South Grand River at this point was a larger river (stream order 7). It received discharges of treated sewage effluent from Clinton (total P.E.=23,160) and Deepwater, Missouri (P.E.=700). The treatment facilities serving Clinton have caused problems in the South Grand River as far back as 1952. The southwest lagoon serving Clinton was considered severely overloaded (Missouri Department of Natural Resources 1976). Four miles of the small tributary receiving this effluent and 1.5 miles of the South Grand River were considered moderately polluted in 1978 (Missouri

Department of Conservation 1978). These point sources were in addition to the non-point problems discussed previously for upstream sites (Table 1).

For the most part, benthic invertebrate community characteristics were comparable to those at Og-80 and Og-100 and increased slightly from those at Og-49 (Fig. 24, Appendix Table A-15). Density, however, averaged 516 organisms per square foot. This was not only the highest at mainstem sites, but was the highest average density in the entire South Grand River Basin. Extremely high concentrations of caddisflies, primarily Cheumatopsyche sp. and Potamyia flava, were responsible for this high abundance (Fig. 25). Caddisflies represented 73% of all benthos collected at Og-17.

Other dominant taxa were:

Caddisflies (73%)		Flies (14%)		Mayflies (6%)	
Cheumatopsyche sp.	62%	Chironomidae	51%	Tricorythodes sp.	44%
Potamyia flava	30%	Simuliidae	48%	Stenonema pulchellum	37%
Hydropsyche cuanis	5%	Empididae	<1%	Isonychia sp.	12%

Water quality in this reach of the South Grand River was considered moderately polluted since characteristic values consistently fell within this range (Table 3). The accumulative effects of chronic upstream problems, primarily non-point erosion, sedimentation, and turbidity, have depressed the invertebrate community in spite of optimal substrate for benthos production. The community as a whole consisted of sensitive and facultative taxa indicating the absence of acute problems. Degradation from upstream point source problems was localized in its immediate effects.

Community similarities and cluster analysis alignment at Og-17 were limited. This community was similar to two sites in the Marais des Cygnes River Basin and only aligned with the community at Omdcm-4 on lower Miami Creek (Fig. 5). The tremendous concentration of Hydropsychid caddisflies was the main reasons for their likeness.

Finally, the community and habitat described at Og-17 in 1975-76 no longer exist. They are presently covered by Truman Reservoir.

Big Creek

Big Creek begins in south central Jackson County and originally flowed for 98 miles before entering the South Grand River, 11 miles upstream from Og-49. Big Creek is an order six stream at its mouth. At Blairstown, Missouri, its watershed is about 414 square miles and its average discharge was 317 cubic feet per second over 14 years (U.S. Geological Survey 1974). Big Creek lies within the Osage Plains Region and most areas are intensively farmed (Fig. 0). Channelization has shortened its original length by 22 miles. Twenty-one miles of Big Creek are within the flood pool elevation of Truman Reservoir. The total length of Big Creek influenced by these two alterations is 37 miles or 38% of the original mileage. The 1978 pollution survey considered the lower 16 miles moderately polluted by non-point sources from drainage and erosion of agricultural lands (Missouri Department of Conservation 1978). Point sources enter Big Creek in the upper portion of the watershed. Discharges from the Pleasant Hill and Garden City drinking water treatment plants and treated sewage effluent from Pleasant Hill (Total P.E.=6,165), Garden City (P.E.=812), Lake Winnebago (P.E.=900) and Raymore, Missouri were identified during this survey (Table 1). These enter tributaries or the mainstem of Big Creek in the upper 33% of its watershed (Table 1). Since Big Creek drains the

Osage Plains Region, strip mining for coal was not profitable. This doesn't mean that mining was non-existent. In the 1950, a few areas drained by Honey Creek, near the mouth of Big Creek, were mined by the Reliance Coal Company. Although some acid drainage problems resulted during that time period, none were evidenced during the present survey.

Big Creek was sampled at Ogb-5, just upstream from the U.S. Highway 7 crossing in Henry County (Fig. 5, Table 2). This site was located downstream from the mouth of Honey Creek in the channelized portion of Big Creek. Its flow was quite sluggish and water clarity was poor during all sampling visits. Substrate consisted solely of silt and organic debris, requiring samples to be collected with artificial substrate samplers (Fig. 2). Sample density was moderate, averaging 169 organisms per square foot. Community characteristics reflected the stress placed on this community by the restricted habitat. These characteristics consistently fell in the polluted range (Table 3) on a seasonal and annual basis (Fig. 26. Appendix Table A-15). Invertebrate community structure also reflected the silty habitat at Ogb-5 (Fig. 27). Aquatic earthworms and midges comprised the vast majority of invertebrates collected at Ogb-5. The facultative taxa that were present tolerated silty habitats as seen by the presence of the mayfly, Hexagenia limbata. The community at Ogb-5 consisted of the following:

Other (52%)		Flies (40%)		Mayflies (5%)	
Oligochaeta	93%	Chironomidae	99%	Stenacron interpunctatum	84%
Argia sp.	5%	Bezzia/ Probezzia, ...,	<1%	Caenis sp.	13%
Lirceus sp.	1%	Simuliidae	<1%	Hexagenia limbata	2%

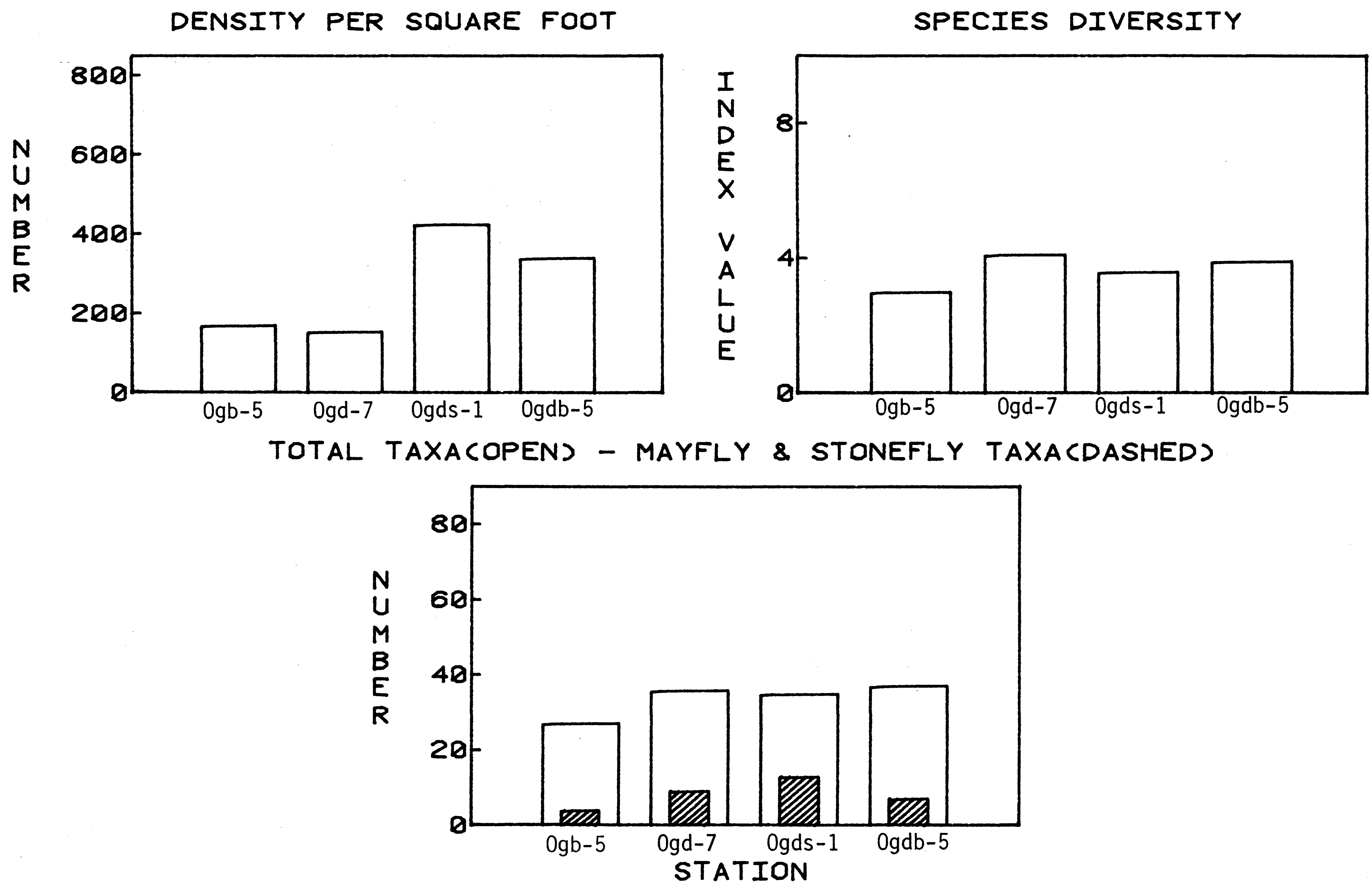


FIGURE 26. BENTHIC INVERTEBRATE COMMUNITY CHARACTERISTICS FOR SAMPLES FROM BIG, DEEPWATER, AND BEAR CREEKS- 1975-76.

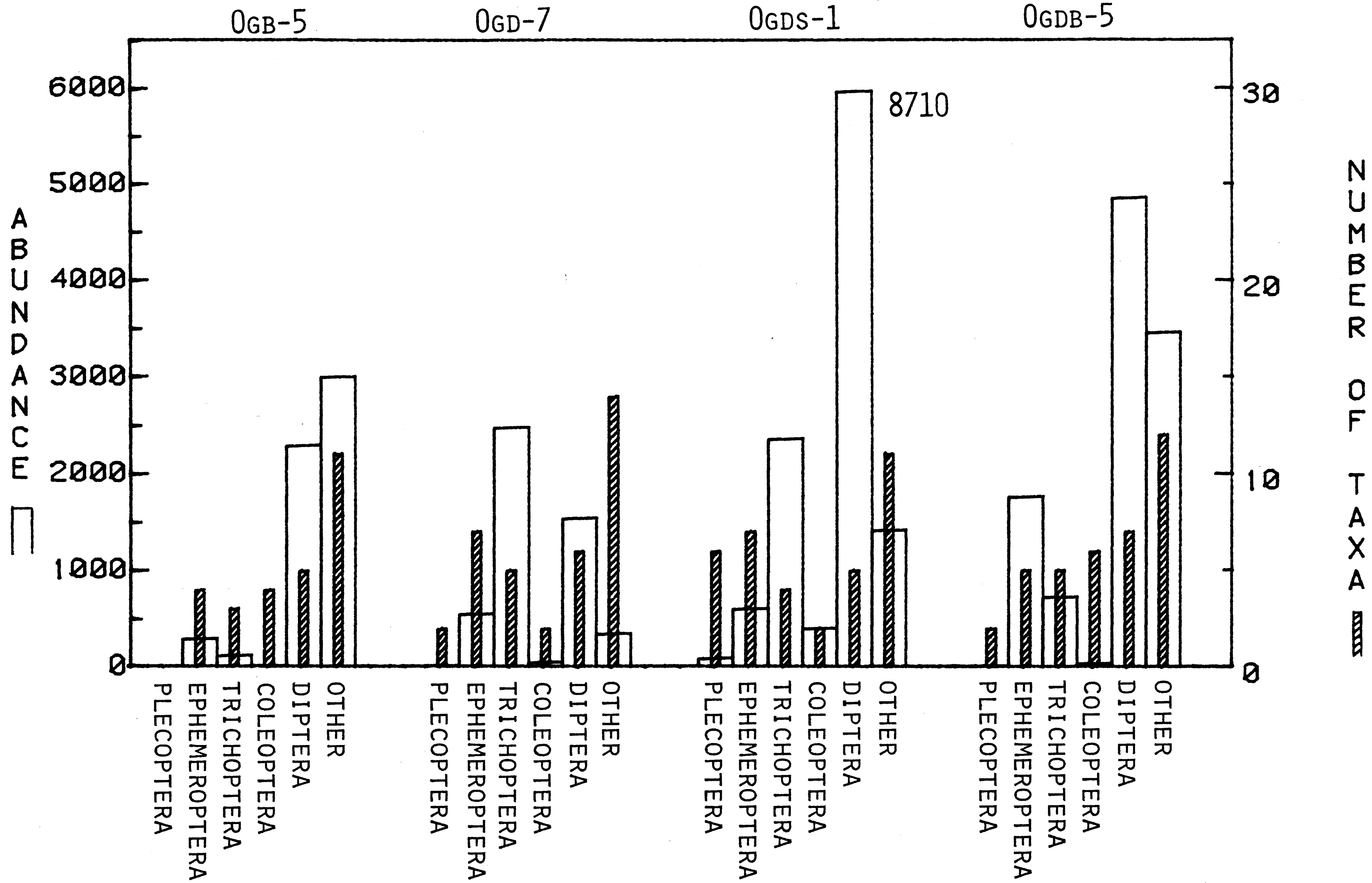


FIGURE 27. COMMUNITY STRUCTURE OF BENTHIC INVERTEBRATES BY ABUNDANCE AND TAXA FOR SAMPLES FROM BIG, DEEPWATER, AND BEAR CREEKS- 1975-76.

Considering the above data, water quality in Big Creek was poorer than most of the previous sites on prairie streams and was classified polluted. The primary cause was chronic problems from non-point sources, mostly agricultural in origin.

The benthos community at Ogb-5 was similar to eight other prairie and intergrade streams. Four of these sites were on the mainstem Osage River (Appendix Table A-23). Most of these similar sites were also included in the same cluster (Appendix Table A-24). This cluster was characterized by Oligochaete-midge dominant communities. The community at Ogb-5 aligned closest to those in Clear Creek, Oc-10 (discussed previously) and in the headwaters of the Little Sac River (Osls-103). Clear Creek was affected by chronic non-point problems and poorly treated sewage effluent from Springfield caused the problems seen in the Little Sac River.

Deepwater Creek

Deepwater Creek drains southeast Bates and southwest Henry counties. The upper 40% of the watershed drains the Osage Plains Region and is farmed intensively. The remaining 31 miles flow across the Cherokee Plains Region (Fig. 0). Strip mining for coal was quite prevalent in this lower portion especially in the Bear Creek area. Earliest reported mining was by Johnson Coal Company in the early 1950's. Mines operated by Peabody Coal Company are still active. Although mining has influenced this lower reach, the inclusion of the entire 31 mile segment (60%) within the boundaries of Truman Reservoir has had the most impact on Deepwater Creek. The completion of Montrose Lake by Kansas City Power and Light Company in 1956 permanently flooded about 8 miles of Deepwater Creek. Truman Reservoir inundated an additional 11 miles and placed the remaining 12 miles within its floodpool. All of Deepwater Creek downstream from the confluence of the North and South branches has been altered.

Deepwater Creek was sampled at two sites in Henry County. The upper site was located on South Deepwater Creek (Ogds-1), upstream from Montrose Lake (Fig. 5, Table 2). This site was located outside the confines of Truman Reservoir. No point source discharges were identified upstream from this site, however, non-point agricultural influences were present. The lower site (Ogd-7) was located upstream from the old Missouri Highway 13 crossing (Fig. 5, Table 2). This site was situated downstream from the mouth of Bear Creek and Montrose Lake. Point source discharges identified during the survey consisted of one small sewage treatment lagoon in the Bear Creek Basin (Table 1). Potential pollution problems in this reach consisted of sedimentation from untreated agricultural lands, drainage from abandoned strip mine land, present strip mining by Peabody Coal Company at their Power Mine, and fly ash problems from Kansas City Power and Light Company. Numerous small fishkills were recorded during the late 1950's and early 1960's caused by alkaline fly ash entering the reservoir. In recent years, a few kills have occurred below Montrose Lake. Dead fish in these recent kills have been primarily shad and crappie. The causes were from discharges of low oxygen water from the lake.

Stream habitat in the upper and lower reaches of Deepwater Creek were different. Substrate at Ogds-1 on South Deepwater Creek consisted of a thin layer of larger shale fragments overlying bedrock. This substrate was similar to that found in Dry Wood Creek, the Little Osage River, and the South Grand River at Og-49 and Og-80. The thin layer of shale made this riffle unstable. Water clarity was variable depending on flow. Periphyton growth was present on the substrate but was not considered excessive.

The habitat in the lower portion of Deepwater Creek at Ogd-7 was

quite different. Substrate was stable, consisting of varying sized fragments of shale. Turbidity appeared more variable and sparse growths of algae were noted on the substrate. Chemically, water in the lower reaches of Deepwater Creek was different from that in the mainstem reaches of the South Grand River discussed previously. Dissolved components in lower Deepwater Creek were elevated. Specific conductance, sodium and sulfates in particular were much higher (Appendix Table A-15). The widest divergence between the two sites on Deepwater Creek was in density. Invertebrate abundance was almost three times higher in South Deepwater Creek (Ogds-1) then at at Ogd-7 (Fig. 26, Appendix Table A-15). In fact, the 424 organisms per square foot at Ogds-1 was the second highest average density recorded in the South Grand River Basin. Taxa at both sites were primarily pollution tolerant or facultative forms. Some sensitive stoneflies, however, were collected, especially, in South Deepwater Creek. Dominant taxa at the two sites consisted of:

Ogds-1

Flies (64%)		Caddisflies (17%)		Other (10%)	
Simuliidae	84%	*Cheumatopsyche* sp.	99%	Sphaeriidae	61%
Chironomidae	15%	*Chimarra obscura*	<1%	Oligochaeta	33%
Empididae	<1%	*Agraylea* sp.	<1%	Nemata	3%

Ogd-7

Caddisflies (50%)		Flies (31%)		Mayflies (11%)	
Cheumatopsyche sp.	99%	Chironomidae	77%	*Caenis* sp.	72%
Agraylea sp.	<1%	Simuliidae	22%	*Stenacron interpunctatum*	17%
Hydroptilidae	<1%	Ephydridae	<1%	*Stenonema femoratum*	6%

The benthos communities at both sites on Deepwater Creek were similar to many communities inhabiting prairie and intergrade streams. The community at Ogds-1 was similar to nine other sites and that at Ogd-7 to 19 sites. Only four sites had benthos communities in common with those in Deepwater Creek (Appendix Table A-23). Cluster analysis also showed this difference by placing the two communities in different clusters (Appendix Table A-24). The community at Ogds-1 aligned with the blackfly-caddisfly community which characterized the Marais des Cygnes River Basin. On the other hand, the community in the lower portion of Deepwater Creek clustered with sites in the Marmaton and Little Osage river basins. This latter cluster was characterized by caddisflies, midges, mayflies and beetles.

Water quality in Deepwater Creek at both sites are classified moderately polluted based on the above data. Degrading effects in upper Deepwater Creek were from agricultural related non-point sources. Non-point drainage from adjacent land and discharges through Montrose Lake were primarily responsible for the problems at Ogd-7. Presently, 63% of Deepwater Creek has been altered by permanent and periodic inundation. Inundation by Truman Reservoir has completely eliminated the habitat sampled at Ogd-7 in 1975-76.

Bear Creek

Water quality in Bear Creek at Ogdb-5 was classified moderately polluted and was not much different from that in South Deepwater Creek at Ogds-1. Density was high at both sites (Fig. 26). There was also very little difference between benthic invertebrate community characteristics and community structure at these two sites (Fig. 27, Appendix Table A-15). The communities in Bear and South Deepwater creeks were similar to the same sets of communities in the Osage River Basin (Appendix Table A-23) and they both

aligned in the cluster dominated primarily by blackflies and caddisflies (Appendix Table A-24). Dominant taxa in Bear Creek were:

Flies (45%)		Other (32%)		Mayflies (16%)	
Simuliidae	69%	*Lirceus* ap.	74%	*Caenis* sp.	89%
Chironomidae	29%	Oligochaeta	19%	*Stenonema femoratum*	8%
Empididae	1%	Sphaeriidae	6%	*Stenacron interpunctatum*	2%
		Caddisflies (7%)			
		Cheumatopsyche sp.	96%		
		Chimarra obscura	3%		

Geographically, Bear Creek is located within the Cherokee Plains Region of the Western Plains Province (Fig. 0). It originates just south of Montrose, Missouri and flows northeast for 14 miles before joining Deepwater Creek. The sampling site on Bear Creek (Ogdb-5) was located 5 miles upstream from this confluence (Fig. 5, Table 2). Substrate at Ogdb-5 was stable and consisted primarily of large rubble with a small percentage of gravel and sand. Periphyton growths on the substrate were also moderate. The only point source discharge identified during the survey was a small lagoon serving Montrose School (Table 1). Most degradation in Bear Creek came from chronic non-point problems associated with agriculture and strip-mining for coal. Peabody Coal Company's Power Mine has been in operation since the mid-1950's. At least one fishkill in Bear Creek has been attributed to acid drainage from this mine (Ryck 1975b). The lower 50% of Bear Creek lies within the flood pool of Truman Reservoir, which has further stressed the invertebrate community.

Tebo Creek

The Tebo Creek Basin drains the northeastern portion of Henry County around Calhoun and Windsor, Missouri. The mainstem (order 5) portion of Tebo Creek was 21 miles long from the junction of its Middle and East Forks to its confluence with the South Grand River. Upstream portions of Tebo Creek consisted of four major branches: East Fork; Middle Fork; Sand Creek; and West Fork. The longest distance from the mouth of Tebo Creek to its watershed divide was by traveling up the East Fork of Tebo Creek. This distance was 42 miles. The entire watershed of Tebo Creek drains the Cherokee Plains Region (Fig. 0). As in other basins draining this region, strip mining for coal has been a principle industry. Most mining activities have been concentrated in the headwaters around Calhoun and Windsor. Mining has been conducted in this area for nearly three decades and pollution problems caused by acid mine drainage have also occurred over this same period of time. Several companies have been responsible for the problems which have plagued the tributaries to Tebo Creek. The East Fork of Tebo Creek was mined by the Bud Jones Coal Company from the mid-1950's to the mid-1960's. Modale Brother's Coal Company continued mining near this stream for a short time during the late 1960's. Pollution and fish kills in the East Fork of Tebo Creek caused by acid mine drainage have been documented over this time period. To date, proper reclamation of these lands has not been accomplished. In addition, the East Fork of Tebo Creek received treated sewage effluent from a badly overloaded lagoon system serving Windsor, Missouri (Missouri Department of Natural Resources 1976, Table 1). A pollution survey completed in 1978 considered 3.5 miles of the East Fork of Tebo Creek moderately polluted by these point source discharges. An additional 3 miles were polluted by non-point acid mine drainage (Missouri Department of Conservation 1978).

Finally, the lower 2 miles are within the flood pool elevation of Truman Reservoir.

Large acreages within the watershed of the Middle Fork of Tebo Creek were mined between the late 1940's and early 1960's by the Windsor Coal Company. Four miles of this fork, north of Calhoun, were continually acid and classified grossly polluted (Missouri Department of Conservation 1978). Although fishkills in this stream were not as frequent as those in the East Fork of Tebo Creek, the kills which were documented were much more severe. In 1972, 29,000 fish of many species were killed in a 12 mile stretch (Ryck 1973b). The mined lands in this watershed remain abandoned and have not been reclaimed to date.

Portions of the watersheds of the remaining two branches, Sand Creek and the West Fork of Tebo Creek, were mined by Peabody Coal Company at their Tebo Mine between the early 1960's and 1979. Although some acid mine drainage has been documented in these branches, pollution problems with regard to frequency and magnitude have been less than in the previous branches. One fishkill from acid drainage was investigated in Sand Creek during 1972 (Ryck 1973b). A total of 26,000 fish were killed in a 6 mile reach. No major problems have been documented in the West Fork of Tebo Creek. Some reclamation and better mining methodology by Peabody Coal Company were in part responsible for the fewer problems.

In areas of Tebo Creek not influenced by surface mining, much of the watershed was intensively farmed. As in other Western Plains Province streams, erosion of these lands and sedimentation in Tebo Creek influenced the water quality. Effects from point source discharges entering these branches were minimal and localized. In Sand Creek, the only source identified was the sewage treatment lagoon serving Leeton, Missouri (P.E.=395) which discharged into the extreme headwaters (Table 1).

The completion of Truman Reservoir in 1978 has dramatically altered the habitat in Tebo Creek and its tributaries. Twenty of the 21 miles of mainstem Tebo Creek have been permanently covered with water. This includes the site (Ogt-18) sampled in 1975-76 (Fig. 5). The remaining mainstem mile was included in the floodpool. None of the mainstem mileage of the four branches were permanently inundated; however, varying portions were within the floodpool and are periodically flooded. The mainstem lengths of each branch included in the floodpool of Truman Reservoir are: East Fork of Tebo Creek, 2 miles (12%); Middle Fork of Tebo Creek, 3 miles (27%); Sand Creek, 8 miles (47%); and West Fork of Tebo Creek, 6 miles (40%). In total, there are 273 miles of order 2 or larger streams in the Tebo Creek Basin. Thirty-one percent or 84 miles have been altered by periodic or permanent flooding.

Tebo Creek and its four branches were monitored at five sites during 1975-76. These sites were strategically located to evaluate the effects of upstream pollution problems. The sample site on the East Fork of Tebo Creek (Ogte-5) was located outside the confines of Truman Reservoir at a Henry County road crossing 3 miles east of Calhoun, Missouri (Fig. 5, Table 2). Samples were collected from a stable shale fragment riffle consisting of gravel-sized material that was quite uniform. The water in this reach was generally clear, temperatures were moderate, flow was good, and periphyton growths were not considered excessive. Benthic invertebrate community characteristic values for samples from Ogte-5 were intermediate when compared to values from the other four sites (Fig. 28). Density was considered moderate to high, averaging 259 organisms per square foot (Appendix Table A-15). Community characteristics consistently fell in the moderately polluted range (Table 3). The community inhabiting the East Fork of Tebo Creek was comprised of tolerant, facultative and some sensitive taxa (Fig. 29). The water quality in this branch was classified moderately polluted. A combination of point and non-point problems upstream from Ogte-5 were considered the cause. The most numerous taxa collected at this site were:

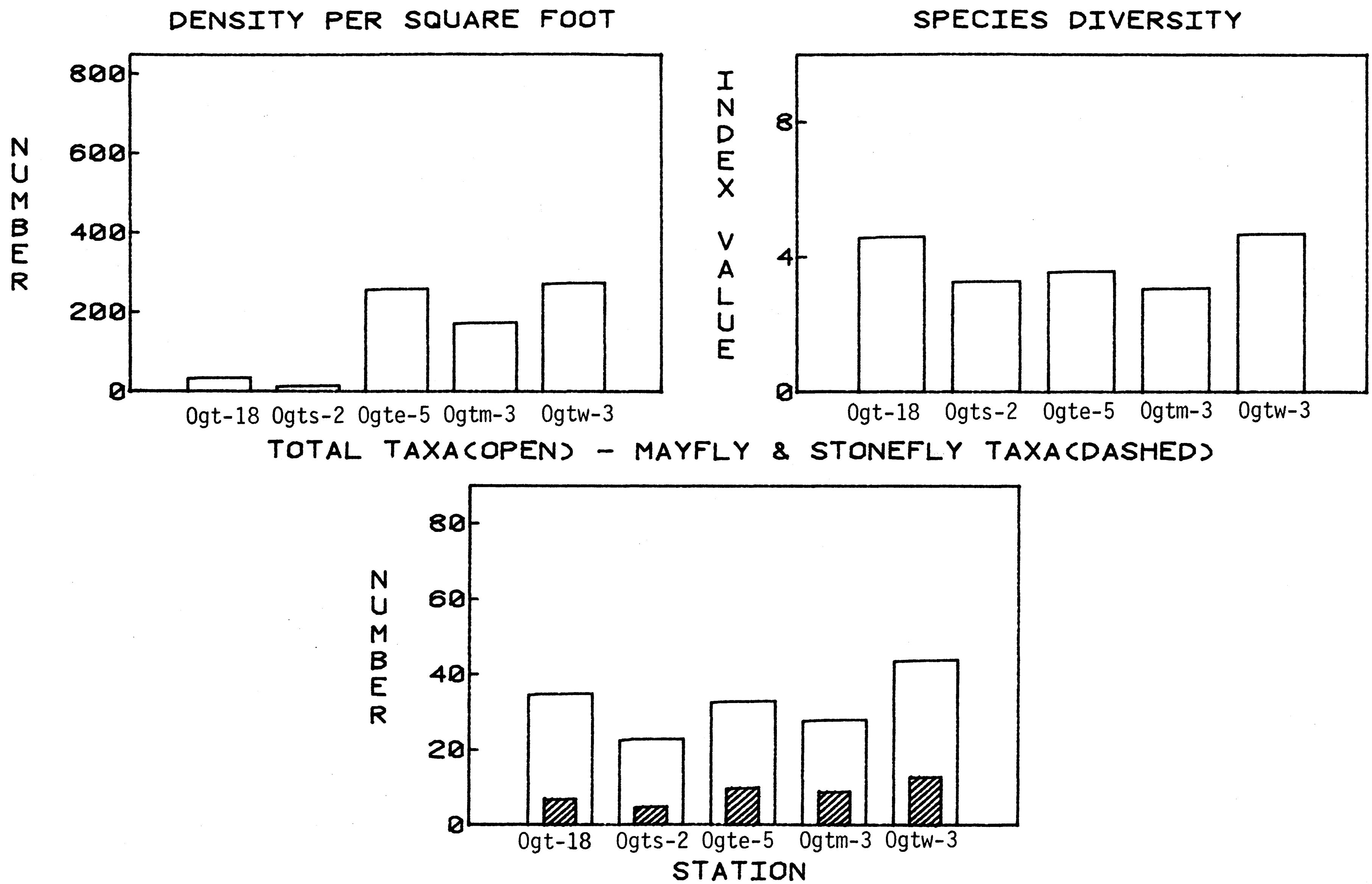


FIGURE 28. BENTHIC INVERTEBRATE COMMUNITY CHARACTERISTICS FOR SAMPLES FROM TEBO CREEK AND TRIBUTARIES- 1975-76.

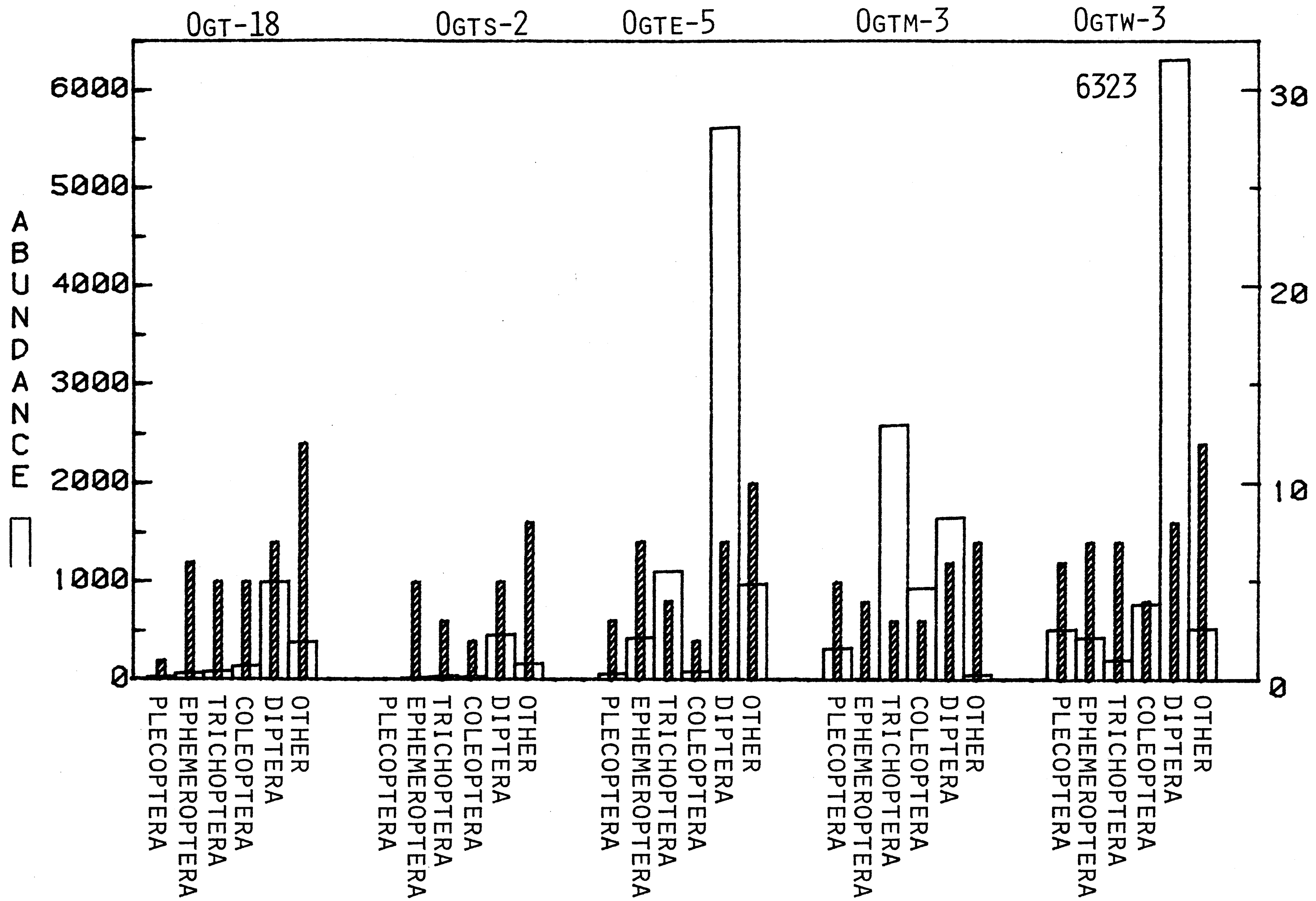


FIGURE 29. COMMUNITY STRUCTURE OF BENTHIC INVERTEBRATES BY ABUNDANCE AND TAXA FOR SAMPLES FROM TEBO CREEK AND TRIBUTARIES- 1975-76.

Flies (68%)		Caddisflies (13%)		Other (12%)	
Chironomidae	63%	*Cheumatopsyche* sp.	97%	Oligochaeta	83%
Simuliidae	36%	*Chimarra obscura*	2%	Sphaeriidae	5%
Empididae	<1%	*Hydropsyche cuanis*	<1%	*Lirceus* sp.	4%

Water quality conditions in the Middle Fork of Tebo Creek were poorer than those in the previous branch. Water quality was classified polluted primarily because benthic invertebrate community characteristics fell consistently in this range (Fig. 28, Appendix Table A-15, Table 3) and few sensitive taxa were represented at this site (Fig. 29). Density at Ogtm-3 was lower than at the previous site, averaging 175 organisms per square foot. This was considered moderate. Site Ogtm-3 was located at a low water crossing 1.5 miles north of Calhoun (Fig. 5, Table 2). This location was on the lower edge of the section severely affected by acid mine drainage (Missouri Department of Conservation 1978) and on the floodplain elevation of Truman Reservoir. Water samples collected in 1973 and 1974 had high sulfate and specific conductance values and low pH and alkalinity. These values reflected the severe problems with acid mine drainage in the Middle Fork of Tebo Creek from abandoned lands mined by Windsor Coal Company (Appendix Table A-5). Similar chemical conditions were found in Sand Creek (Ogts-2) and Deepwater Creek below Montrose Lake (Ogd-7). Substrate at Ogtm-3 was identical to that found in the East Fork of Tebo Creek. The riffle was stable, flow was good, and temperatures were moderate. Periphyton growths, however, were much reduced over those in the East Fork of Tebo Creek in spite of clearer water.

The benthos community inhabiting Middle Fork of Tebo Creek was similar in structure to those in the Marmaton-Little Osage River Basin. This

community clustered with four of the six sites in that basin (Appendix Table A-24) and had coefficients of similarity greater than 50 with 15 sites in the Osage River Basin (Appendix Table A-23). Eighty percent of these similar sites were on prairie and intergrade streams. The most abundant taxa in the Middle Fork of Tebo Creek were:

Caddisflies (46%)		Flies (30%)		Beetles (17%)	
Cheumatopsyche sp.	84%	Chironomidae	50%	*Stenelmis* sp.	99%
Chimarra obscura	15%	Simuliidae	44%	*Dubiraphia* sp.	<1%
Agraylea sp.	1%	*Hexatoma* spp.	4%	*Berosus* sp.	<1%

West Fork of Tebo Creek was sampled downstream from a low water crossing, 3 miles southwest of Calhoun (Fig. 5, Table 2). The habitat at this site (Ogtw-3) was similar to the previous two sites, however, the substrate was comprised of a wider variety of shale fragments and created a good, stable riffle for benthos production. Water clarity at Ogtw-3 was quite clear and periphyton production appeared comparable to that at Ogte-5. The watershed of the West Fork of Tebo Creek was primarily farmland, however, some areas were being actively mined for coal by Peabody Coal Company during the survey. Water quality in the West Fork of Tebo Creek appeared to be the best of the five sites in the Tebo Creek Basin, however, it was still classified as moderately polluted. The degradation was primarily from non-point sources. Density was considered moderately high, averaging 274 organisms per square foot. This was the highest average density recorded at the five sites (Fig. 28, Appendix Table A-15). Benthic invertebrate community characteristics were also higher at Ogtw-3 than at the other four sites. These

characteristics consistently fell in the moderately polluted range on a seasonal and annual basis (Table 3). A wider variety of pollution sensitive taxa were also present (Fig. 29). Better reclamation of mined lands by Peabody Coal Company in this fork when compared to the previous branches was in part responsible for the improved water quality.

The benthos community in the West Fork of Tebo Creek at Ogtw-3 clustered in the same group as Ogte-5 (Appendix Table A-24). This cluster consisted of 14 sites primarily on prairie and intergrade streams and the mainstem Osage River. The community at Ogtw-3 was almost identical (C=78) to the community in the East Branch of the South Grand River (Oge-7) whose water quality was considered quite good. Dominant benthos in samples collected at Ogtw-3 were:

Flies (72%)		Beetles (9%)		Other (6%)	
Chironomidae	94%	*Stenelmis* sp.	98%	Oligochaeta	82%
Simuliidae	4%	*Dubiraphia* sp.	1%	Sphaeriidae	12%
Bezzia/ *Probezzia*, ...,	1%	*Berosus* sp.	<1%	*Physa* sp.	2%

Stoneflies (6%)
Allocapnia sp.
Perlesta placida
Neoperla sp.

The fourth branch of Tebo Creek sampled in 1975-76 was Sand Creek. Chemically, the water in Sand Creek had characteristics typical of streams draining coal mine lands. Many of the parameters were similar to those in the Middle Fork of Tebo Creek and Deepwater Creek (Appendix Table A-5).

The aquatic habitat, however, was quite different. This riffle substrate consisted almost exclusively of sand and organic debris with a small percentage of gravel and no rock or rubble sized material. The integrity of this riffle was unstable and very difficult to sample. Water clarity was moderately turbid during most sampling trips and periphyton growths were sparse. Average density of samples collected at Ogts-2 (Fig. 5, Table 2) was 15 organisms per square foot. This was the lowest density in the South Grand River Basin (Appendix Table A-15) and second only to the Sac River below Stockton Dam (Os-49) within the entire Osage River Basin. Community characteristic values were also low (Fig. 28, Appendix Table A-15), consistently falling in the polluted range (Table 3). Of the 23 total taxa collected, most were pollution tolerant or facultative. Water quality in Sand Creek was considered polluted, however, the cause(s) of this condition were not clear. A combination of factors including non-point runoff from mining and agricultural lands and poor habitat were primarily responsible for the benthos community at Ogts-2 (Fig. 29). This community consisted of the following:

Flies (63%)		Other (23%)		Caddisflies (5%)	
Chironomidae	90%	Oligochaeta	88%	*Cheumatopsyche* sp.	95%
Simuliidae	8%	Sphaeriidae	6%	*Ochrotrichia* sp.	3%
Chrysops sp.	1%	*Lirceus* sp.	2%	*Pycnopsyche* sp.	2%

The benthic invertebrate community at Ogt-18 (Fig. 5, Table 2), downstream from the confluence of the preceding four branches, clustered with the community in Sand Creek and three other sites (Appendix Table A-24).

All five of these sites had marginal habitat for benthos production. Even though the structure of the community at Ogt-18 was similar to that at Ogts-2 (Fig. 29), it was most similar to the community at 0-4, near the mouth of the mainstem Osage (C=70). Dominant taxa at Ogt-18 were:

Flies (58%)		Other (23%)		Beetles (8%)	
Chironomidae	88%	Oligochaeta	85%	*Stenelmis* sp.	89%
Hexatoma spp.	6%	Sphaeriidae	10%	*Dubiraphia* sp.	8%
Simuliidae	5%	Nemata	1%	*Berosus* sp.	1%

Water quality at this site was classified polluted even though some benthic invertebrate community characteristics fell in the moderately polluted range (Fig. 28, Appendix Table A-15, Table 3). Density was quite low, averaging 36 organisms per square foot, and mayfly and stonefly taxa were very limited. Many of the taxa that were present were in low numbers. Chemically, water analyzed from this portion of Tebo Creek had characteristics which showed the influences of upstream acid mine drainage, however, the values for pH, specific conductance and sulfate were not as high as those found in Sand Creek and the Middle Fork of Tebo Creek (Appendix Table A-5). The substrate at Ogt-18 was similar to that in Sand Creek and the mouth of the Osage River. It consisted primarily of fine materials. Water clarity was moderately turbid and periphyton growths were very sparse.

The chronic effects of non-point agricultural pollutants appeared to be uniform throughout the Tebo Creek Basin. The varying degree of degradation in the different branches was caused by the amount of (or lack of) reclamation done by the various companies which mined in the basin. The completion of

Truman Reservoir inundated Ogt-18 and the floodpool periodically affects two of the four remaining sites. As mentioned previously, 31% of the basin was influenced by Truman Reservoir. An additional 10.5 miles of stream were judged polluted (Missouri Department of Conservation 1978). In all, a total 35% (94.5 miles) of the Tebo Creek Basin was degraded by human related activities.

Overall, water quality in the South Grand River Basin was much like that in the Marmaton-Little Osage River Basin for the same reasons. Of the 14 sites, the water quality at one site (Oge-7) was considered unpolluted, nine sites were moderately polluted, and the remaining four sites were classified polluted. Degrading influences were primarily from three general sources. Chronic sedimentation from intensive agriculture was felt to have a general degrading effect throughout the entire basin. The site least effected by these chronic problems was on the East Branch of the South Grand River (Oge-7) while Big Creek (Ogb-5) appeared to suffer the most degradation from erosion, sedimentation and channelization. Acid drainage from abandoned strip mine lands was the second degrading influence. These problems were most severe in the Tebo Creek Watershed. Acid problems were also apparent in Deepwater Creek but appeared less severe. Finally, this basin was affected by point source discharges but these effects were generally localized. Normally, the smaller tributaries showed degradation from these discharges because of lower dilution rates. In all, a minimum of 51 miles in the South Grand River Basin was degraded by point and non-point pollution. An additional 98 miles were permanently inundated by Truman Reservoir and another 206 miles are periodically flooded. In total, a minimum of 355 miles (16%) of order 2 or larger streams within this basin have been seriously altered.

Biologically, the invertebrate communities at the 14 sites throughout

the South Grand River Basin were not as homogeneous as those in the Marais des Cygnes and Marmaton-Little Osage river basins. In general, invertebrate densities at sites in the South Grand River Basin were moderate and variable, averaging 227 organisms per square foot. These values ranged from 15 at Ogts-2 on Sand Creek to 514 at the mouth of the mainstem (Og-17). Community characteristics were also variable but generally fell into the polluted or moderately polluted range depending on the site. Community structure was similar to other prairie stream sites but different in composition. The 14 sites clustered in five groups. In general, these clusters consisted of community types from prairie stream sites.

As in the previous basins, improved water quality in the South Grand River and its tributaries will only be seen when chronic point and non-point problems are resolved. Specifically, improved farming techniques which reduce erosion and sedimentation must be adopted, abandoned strip mine land must be reclaimed, and point discharges must meet standards.

Sac River

The Sac River and most of its major tributaries drain the Springfield Plain Region of the Ozark Highland Province (Fig. 0). According to Collier (1959), this region is transitional between the gentle slopes, more productive soils and increased mineral resources of the Western Plains and the reverse of these conditions which exist in the remainder of the Ozark Highland Province. The streams within the Springfield Plain Region also tend to intergrade between true Ozark and prairie streams. Geographically, this region was included in the Ozark Highland Province because overall characteristics and local usage seem to place it there (Collier 1959). Likewise, overall characteristics of the Sac River and most of its tributaries

are most like Ozark streams. Horse and Cedar creeks are probably the best examples of true intergrade streams because they border the two provinces and clearly possess characteristics of both prairie and Ozark streams.

The effects of non-point pollution problems were present in the Sac River Basin but their effects were not as obvious as in the Western Plains Province. The conspicuous reduction of fine silts and clays in the substrate and an improvement in water clarity throughout much of the basin were just two characteristics which suggest the decreased influences of non-point pollution on water quality. The primary influences on water quality within the Sac River Basin were point source discharges and impoundments constructed by the U.S. Army Corps of Engineers. Together they have affected over 300 miles of streams or 17% of the entire Sac River Basin.

Seventy-nine species of fish have been collected from the Sac River Basin (Table 4). Sixteen families were represented in these collections. Included in this species list is the Niangua darter (*Etheostoma nianguae*) which is rare in Missouri (Nordstrom, Pflieger, Sadler and Lewis 1977) and been recommended for inclusion on the Federal list of *Threatened Wildlife of the United States*. This species is known to inhabit two tributaries of the Sac River, Brush Creek and the North Dry Sac River (Pflieger 1978). One hundred and seventy-two taxa of benthic invertebrates were collected from the 20 sites in the Sac River Basin. Included in this number were 44 taxa of pollution sensitive mayflies and stoneflies (Table 5). These statistics indicate the Sac River Basin has one of the most diverse benthic invertebrate faunas within the Osage River Basin. This variety of benthos was equalled only by the number of taxa collected from the 20 sites on the minor mainstem tributaries of the Osage River. The variety of niches created in this transition zone between the prairies and the Ozarks is in part responsible

for the greater variety of aquatic invertebrates present. This greater diversity of taxa and the increased number of senstive taxa has also been helped by the decreased influence from chronic non-point pollution problems which plagued the prairie streams.

Sac River (Mainstem)

The mainstem of the Sac River originates in west-central Greene County and flows north across the Springfield Plain Region for 129 miles before entering the Osage River just west of Osceola, Missouri (Fig. 4). The construction of two large reservoirs have impacted 62% of this mainstem (Fig. 1). Truman Reservoir has permanently inundated the lower 9.5 miles and placed another 26 miles in its flood pool. Stockton Dam was completed at river mile 50 in 1969 and permanently backed up water for another 38 miles. An additional 7 miles of the mainstem Sac River are within the flood pool elevation of Stockton Reservoir. Flow from Stockton Dam is highly variable because of hydropower generation. The 14 miles of the Sac River between Stockton Dam and the upper limit of Truman Reservoir has been seriously degraded. This variation in flow has created a very unstable environment in this reach by accelerating bank erosion and causing sedimentation problems. Only the upper 25% of the Sac River has not been altered from its original state.

Water quality in the Sac River was monitored at five sites throughout its course. The upper two sites, Os-82 and Os-86, were situated above and below the mouth of Clear Creek (Fig. 4). Os-49 was situated about halfway down the mainstem of the Sac River, 0.5 miles below Stockton Dam. The effects of variable flows resulting from hydropower generation through the dam were monitored at this site. The lower two sites were established below Caplinger Mills Dam (Os-35) and near the mouth (Os-4). These sites monitored changes, if any, in the lower reaches.

Sites Os-86 and Os-82 were located on order 5 reaches of the Sac River in Greene and Dade counties, respectively (Fig. 4, Table 2). The aquatic habitat at these sites was quite similar. The sampling sites consisted of stable riffles separated by medium length pools. Substrate consisted of limestone fragments which varied widely in shape and size. This substrate type closely resembled the substrate found in the Ozark Highland Province and was a departure from the shale fragment riffles of the Western Plains Province. Water clarity was mostly clear, turning dingy during periods of heavy runoff. Water temperatures were considered moderate. Seven small springs enter headwater tributaries of the Sac River upstream from Os-86 and another 12 enter Clear Creek which joins the Sac River, upstream from Os-82. Together, these groupings of small springs account for 37% of the springs in the Sac River Basin (Vineyard and Feder 1974). The largest of these 19 springs was Hayes Spring which had a maximum recorded discharge of 1,630,000 gallons per day.

Pollution sources, upstream from Os-86 were primarily discharges of treated sewage effluent. The effluent from three small lagoons (total P.E.=160), a trickling filter plant serving Ash Grove, Missouri (P.E.=1,600), and a 3-cell lagoon system serving Republic (P.E.=7,500) entered small tributaries to the Sac River in its extreme headwaters (Table 1). Four miles of Dry Branch Creek which received the effluent from Ash Grove was considered moderately polluted in 1978 (Missouri Department of Conservation 1978). Two small lagoons (total P.E.=382) discharge into the Sac River upstream from Os-82 via Clear Creek. These were the only major sources of pollution identified during this survey. Non-point problems were considered minimal since much of the watershed upstream from Os-82 was in permanent pasture or forest.

Water quality in the Sac River in the vicinity of Os-82 and Os-86 was classified as unpolluted. Benthic invertebrate community characteristics

were consistently above minimum criteria for unpolluted Missouri streams on a seasonal and annual basis (Fig. 30, Appendix Table A-17, Table 3). Density was considered moderate at Os-86 and moderately light at Os-82 (Fig. 30). These characteristics and the diversity of sensitive taxa (Fig. 31) indicated good water quality in the upper Sac River. However, the presence of heavy periphyton and algae growths during low water periods indicated some potential problems with nutrient enrichment. The growths were most prevalent at Os-86. This enrichment had not reached detrimental proportions as of 1975-76, however, continued non-abatement of these headwater problems could alter future water quality in the upper Sac River.

The benthos communities at the two sites (Os-86 and Os-82 were similar to ten and seven sites, respectively, and quite similar to each other (C=61). Similar sites were located on other intergrade streams within the Sac River Basin (Appendix Table A-23). Similarities did not exist with prairie streams. These two sites clustered in the same grouping dominated by mayflies, midges, and beetles. Seven other Ozark and intergrade streams were included this cluster (Appendix Table A-24). The similarity and clustering of these two sites with other unpolluted streams further attests the relatively good condition in the upper Sac River and the lack of influence from Clear Creek.

Dominant taxa at these two sites were:

Os-82

Beetles (33%)		Flies (28%)		Mayflies (25%)	
Optioservus sandersoni	63%	Chironomidae	74%	Rhithrogena sp.	24%
Stenelmis sp.	36%	Bezzia/ Probezzia, ...,	13%	Stenonema mediopunctatum	19%
Psephenus herricki	<1%	Simuliidae	10%	Ephemerella needhami	13%
				S. pulchellum	11%

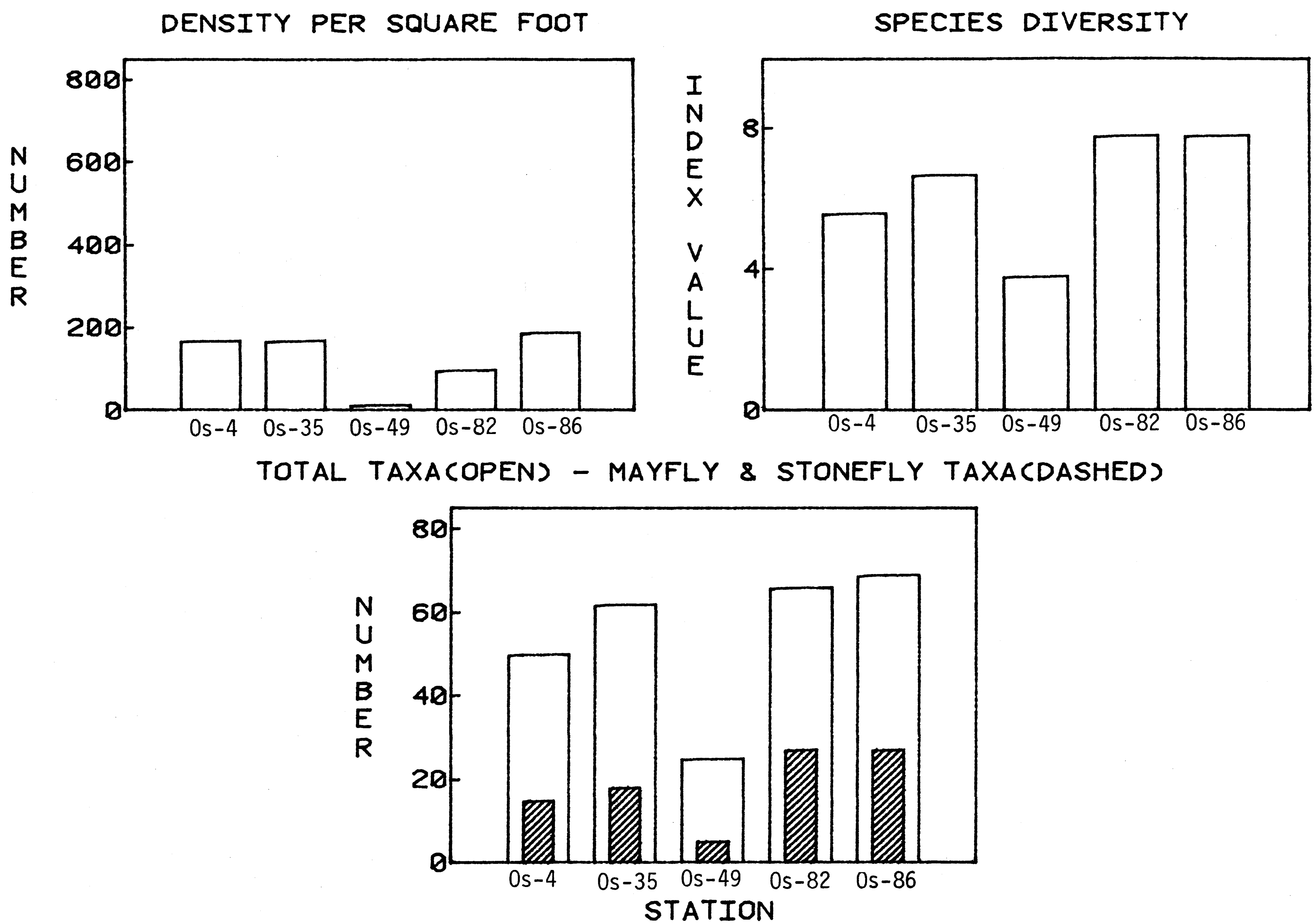


FIGURE 30. BENTHIC INVERTEBRATE COMMUNITY CHARACTERISTICS FOR SAMPLES FROM THE MAINSTEM SAC RIVER- 1975-76.

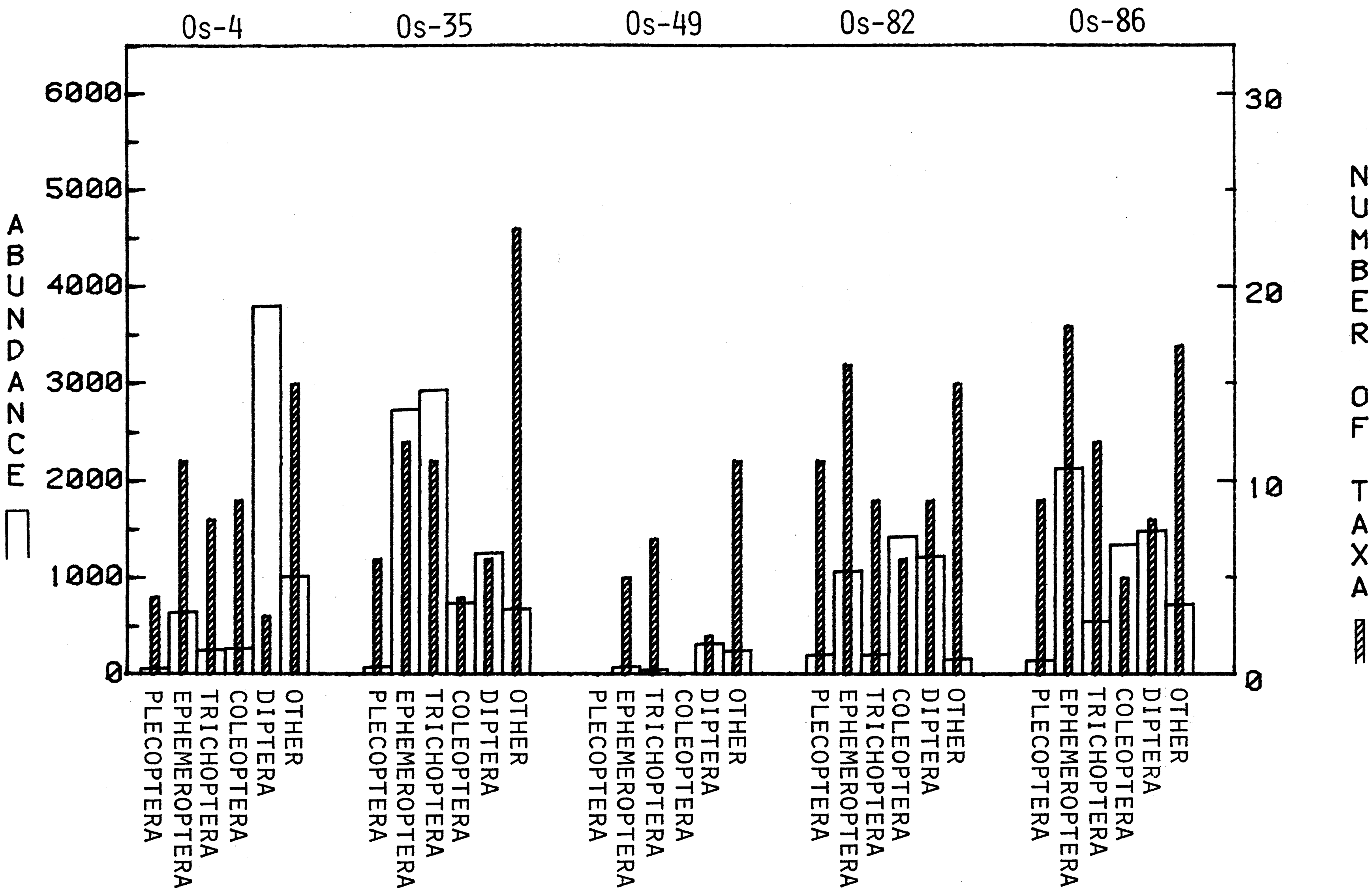


FIGURE 31. COMMUNITY STRUCTURE OF BENTHIC INVERTEBRATES BY ABUNDANCE AND TAXA FOR SAMPLES FROM THE MAINSTEM SAC RIVER- 1975-76.

Os-86

Mayflies (33%)		Flies (23%)		Beetles (21%)	
Stenonema mediopunctatum	17%	Chironomidae	76%	Optioservus sandersoni	73%
S. pulchellum	17%	Simuliidae	11%	Stenelmis sp.	19%
Rhithrogena sp.	15%	Bezzia/ Probezzia, ...,	10%	Psephenus herricki	7%
		Atherix lantha	2%		

Water quality just downstream from Stockton Dam was quite different from the previous two sites. Site Os-49 was located at a permanent riffle about 0.5 miles below the dam (Fig. 4, Table 2). Substrate consisted of varying sized fragments of limestone rock. Sizes varied from fine sand to coarse rock and rubble. The latter category made up the majority of this stable riffle. Water clarity was generally clear since the site could only be sampled during periods of non-generation. Periphyton growths during extended periods of minimum flow were sometimes quite dense. Flow at Os-49 was extremely variable. During 1975-76, the average daily discharge was 1443 cubic feet per second and ranged from a low of 36 cubic feet per second to a high of 5250 (U.S. Geological Survey 1976). These extremes could be reached in less than 24 hours. Water temperatures averaged slightly lower than surrounding streams and were regulated by the temperatures in the lake and the frequency of discharges through the dam.

After Stockton Lake filled in 1969, severe problems developed from extended periods of low dissolved oxygen concentrations in this reach of the Sac River at the onset and during power generation. This was caused by decaying vegetation in the reservoir and by drawing water through the turbines from the hypolimnion after the lake had stratified. Two fish kills occurred in this portion of the Sac River after the dam was completed. One occurred

in 1970 and the other in 1973 (Ryck 1973b). Approximately 20,000 fish died in 3 miles of the Sac River during the first kill. Less than 100 fish died during the second kill, however, numerous fish were found in distress. Low oxygen concentrations (1 milligram per liter or less) caused these deaths. Prior to middle 1973, deoxygenated hypolimnion water passed directly through the turbines continuously. According to Vandenberg and Patton (1976), the benthic invertebrate community at Os-49 was much reduced and indicative of very poor water quality. In July 1973, Corps of Engineers completed the installation of a skimming weir upstream from the dam. The weir was designed to allow well oxygenated epilimnion water to be drawn through the turbines instead of deoxygenated water from the hypolimnion. Continuous chemical monitoring of dissolved oxygen concentrations before, during, and after the onset of power generation was done in August 1973. The 1973 Missouri Water Quality Standards set 5 milligrams per liter as the minimum allowable dissolved oxygen levels in warm water streams. The August 1973 data documented that dissolved oxygen levels were below this standard for about 1 hour following the onset of power generation. After this time, oxygen levels increased and remained at acceptable levels.

Water quality at Os-49 during 1975 and 1976 was still classified as polluted. This was probably an improvement over conditions which existed prior to the installation of the weir. Invertebrate density at this site was very low, averaging 14 organisms per square foot (Fig. 30). This was the lowest average density observed in the entire Osage River Basin. Community characteristics were also quite low falling mostly into the polluted range (Appendix Table A-17, Table 3). Although a few sensitive taxa were present in these samples, most taxa were types tolerant of adverse conditions. Beetle larva and sensitive stonefly nymphs were not collected at Os-49 (Fig. 31).

Benthos samples collected from Os-49 in 1980 showed that water quality conditions remained unchanged. Seasonal community characteristics were virtually identical to those in 1976 samples. The community structure was also similar (C=55). The highly variable flows in this reach have created an unstable environment. The resulting stress has produced the degraded conditions which exist. Water quality in this reach of the Sac River has essentially been the same since the dam was closed in 1969. Only the cause or combination of causes have varied. A more uniform, stable flow regime which closely followed the flows in the Sac River prior to 1969 would undoubtedly improve these degraded conditions.

The community at Os-49 clustered with the low density midge, Oligochaete, fingernail clam, mayfly communities found in Little Dry Wood Creek (Omlw-9), Sand Creek (Ogts-2), Tebo Creek (Ogt-18), and the mouth of the Osage River (O-4). The habitat at all these sites was very poor but for different reasons all caused by human activity. The community at Os-49 most closely clustered with the community in Sand Creek. The Sac River community consisted of the following major taxa:

Flies (45%)		Other (35%)		Mayflies (11%)	
Chironomidae	99%	Oligochaeta	37%	_Stenacron interpunctatum_	41%
Simuliidae	1%	Sphaeriidae	25%	_Caenis_ sp.	34%
		Ferrissia sp.	16%	_Stenonema femoratum_	16%

Water quality conditions at the next site (Os-35), located about 15 miles downstream from Stockton Dam, were much improved. The sampling site

was located about 150 yards downstream from the Caplinger Mills dam (Fig. 4, Table 2). This concrete structure is an old, low head dam which was used to provide power to operate a grist mill. Today, it helps to reduce the range of flow variation between generation and non-generation periods. The aquatic habitat at the sample site consisted of a large, stable riffle composed of limestone fragments which varied widely in size and shape. Water clarity was clear and temperatures were slightly warmer than those below Stockton Dam. Periphyton growths were also less dense than those at Os-49. The more stable flow regime at Os-35 has been responsible for greatly improving the aquatic habitat at this site and reducing the stress on the aquatic communities which live there.

Some sources of non-point pollution have been identified in the Sac River between Os-35 and Os-49. Excessive amounts of bank erosion have caused sedimentation problems in this reach. The primary reason for this erosion is the rapid rise and decline in water levels during power generation periods. Point source discharges were limited to discharges from Stockton, Missouri (P.E.=1200), a small mobile home park (P.E.=172), a cheese factory, and leachate discharge from a landfill (Table 1). These sources were located some distance from Caplinger Mills and entered tributaries to the Sac River. The 1978 pollution survey conducted by the Department classified 2 miles of Stockton Branch, which receives treated sewage effluent, moderately polluted (Missouri Department of Conservation 1978).

Caplinger Mills is the uppermost boundary of the flood pool of Truman Reservoir. Periodic flooding could affect this reach and cause some degradation in this riverine environment.

Water quality in this reach was classified unpolluted because benthic invertebrate community characteristics were high and in most cases exceeded

minimum criteria for unpolluted Missouri streams (Appendix Table A-17, Table 3). Sensitive mayfly and stonefly taxa were the only characteristic which approached but did not exceed these criteria. This could indicate some influence of the varying water levels associated with power generation. Invertebrate density was considered moderate, averaging 168 organisms per square foot (Fig. 30). The most unique feature of this site was that this riffle supported a tremendous number and variety of freshwater naiades. A total of 9 species were identified at this site with very little sampling effort. Naiades are very sensitive towards adverse conditions and their presence in good numbers suggest that the degrading upstream influences are not a severe problem in this reach.

Community characteristics for sampling done in 1980 at Os-35 were almost identifical to the 1976 samples. This similarity shows little change in the water quality at Os-35 over that time span.

Sixteen sites had communities similar to that at Os-35. Forty-four percent of the sites were on prairie streams, 44 percent were on Ozark streams and the remainder were on intergrade streams within the Sac River Basin (Appendix Table A-23). This even dispersal of the similar sites attests to the intergrade nature of this habitat. The community at Os-35 clustered with 17 sites dominated by midges, Tricorythid mayflies, and Cheumatopsychid caddisflies (Appendix Table A-24). Most of the sites in this cluster (71%) were on Ozark type streams. Dominant taxa at Os-35 included:

Caddisflies (35%)		Mayflies (32%)		Flies (15%)	
Cheumatopsyche sp.	95%	*Tricorythodes* sp.	69%	Chironomidae	89%
Ochrotrichia sp.	3%	*Stenonema pulchellum*	24%	Simuliidae	9%
Helicopsyche borealis	<1%	*Potamanthus* sp.	3%	Empididae	<1%
Cyrnellus marginalis	<1%				

Beetles (9%)	
Stenelmis sp.	99%
Ectopria nervosa	<1%

The Sac River was sampled 4 river miles from its confluence with the Osage River at Os-4 (Fig. 4, Table 2). At present, the 9 lower miles of the Sac have been permanently flooded by Truman Reservoir and this sampling site no longer exists. In 1975-76, the aquatic habitat at Os-4 was quite different than that at Os-35. Stream gradient in the lower Sac River was low and this lower reach was one continuous, slow-moving pool. Substrate at this site was fine silt and debris. Water clarity was normally slightly turbid and water temperatures no longer appeared to be influenced by discharges from Stockton Dam. Chemically, water in this portion of the Sac River resembles that in the South Grand River near its mouth at Og-17 (Appendix Tables A-5 and A-6). Bacterial levels appeared to be slightly elevated but nutrient input did not seem abnormally high.

Sources of point pollution between Os-35 and Os-4 were negligible. One small sewage treatment lagoon (P.E.=82) discharged into a tributary about 12 miles upstream from Os-4.

The absence of riffle areas necessitated the use of artificial substrate samplers (Fig. 2). These samplers were installed in 4 to 6 feet of

water and allowed to colonize for a minimum of 6 weeks before they were retrieved. Average invertebrate density at Os-4 was considered moderate (168 organisms per square foot) and was identical to that at Os-35 (Fig. 30). Sample density, however, was much more stable at Os-4 than at the previous site (Appendix Table A-17). Most community characteristics approached minimum criteria for unpolluted streams and seasonal samples for winter and spring met these criteria (Appendix Table A-17, Table 3). The benthos community at Os-4 consisted of tolerant, facultative, and sensitive taxa. Although non-point pollution problems were present in this reach, their overall effects on water quality and the aquatic community was not great. The less diverse habitat in this reach was a function of natural factors such as gradient rather than drastic alterations by pollution. The resulting diversity and structure of the invertebrate community was therefore considered relatively normal and the water quality was classified unpolluted. Benthic invertebrates which normally live in substrate consisting of silt and debris were present in large numbers (Fig. 31). The dominant taxa at Os-4 consisted of:

Flies (62%)		Other (16%)		Mayflies (11%)	
Chironomidae	95%	Oligochaeta	48%	_Hexagenia limbata_	46%
Bezzia, _Probezzia_, ...,	4%	_Argia_ sp.	20%	_Stenacron interpunctatum_	29%
Simuliidae	1%	_Sialis_ sp.	16%	_Stenonema pulchellum_	8%
		Sphaeriidae	6%	_S. femoratum_	7%

The benthos community at Os-4 clustered with 13 other sites whose communities consisted primarily of midges and aquatic earthworms (Appendix

Table A-24). Nineteen sites had similar communities with Os-4 (Appendix Table A-23). A majority of these sites were on prairie and intergrade streams (68%). These similarities indicate the habitat and community in this reach more closely resembles those of prairie streams.

In general, the mainstem Sac River was a true intergrade between prairie and Ozark streams. The upper 75% takes on the appearance of Ozark streams. The lower fourth which borders the Western Plains Province, more closely resembles prairie streams in habitat type and benthos community composition. Although point and non-point pollution problems were present, their effects were overshadowed by the loss of 62% of the mainstem to periodic and permanent flooding by impoundments.

Little Sac River

The Little Sac River drains the eastern portion of the Springfield Plain Region. In unpolluted reaches, the Little Sac River resembles an Ozark stream in physical habitat and benthos community rather than a prairie stream. It originates in east-central Greene County near Strafford, Missouri and flows north for over 81 miles before joining the Sac River. The Little Sac River is about a fourth the size of the Sac River, and has a 12 year average annual discharge of 220 cubic feet per second near Morrisville, Missouri (U.S. Geological Survey 1980). At this location, the Little Sac River drains approximately 237 square miles.

Vineyard and Feder (1974) list 18 springs which discharge into the Little Sac River throughout its course. As in the upper Sac River, these springs were all quite small, the largest being Fulbright Spring which has a recorded discharge of 2,160,000 gallons per day. Most of these springs were located in the upper portion of the watershed around Springfield, Missouri. Together, these springs comprise 35% of the springs in the Sac River Basin. The benthos data collected showed that this ground water

input into the system had little, if any, influence on the type of communities which inhabited the mainstem Little Sac River. This was also true of upper Sac River which received flow from 19 small springs.

Approximately 38 miles (47%) of the mainstem Little Sac River has been permanently flooded by three reservoirs: Stockton Lake (24,900 acres); McDaniel Lake (226 acres); and Fellows Lake (751 acres). Portions of the remaining 43 miles of free flowing stream have been severely polluted or endangered by a variety of point pollution discharges.

Water quality in the Little Sac River was monitored at three sites along its course (Fig. 4). These sites were strategically located near pollution discharges (Osls-98 and Osls-103) and upstream from Stockton Reservoir (Osls-79). The uppermost site on the Little Sac River was located at the old Highway 13 crossing in Greene County (Fig. 4, Table 2). This site was about 0.5 miles downstream from McDaniel Lake. No point source discharges of pollution were identified upstream from Osls-103 during this survey. Surrounding lands were primarily pasture and woodlands. Aquatic habitat at this site consisted of a stable, gravel riffle with a substrate consisting of finer gravel and sand sized fragments of chert and limestone. Water clarity was generally clear and temperatures moderate. Periphyton growths were dense with the heaviest growths of filamentous algae during the winter and spring.

Average invertebrate density in samples from Osls-103 was moderately high (293 organisms per square foot). Although this was the highest average density in the Little Sac River Basin, it was not much greater than densities at the other two sites (Fig. 32). Benthic invertebrate community characteristics for the samples at Osls-103 were the lowest of the three sites, generally falling in the upper polluted range on a seasonal and annual basis

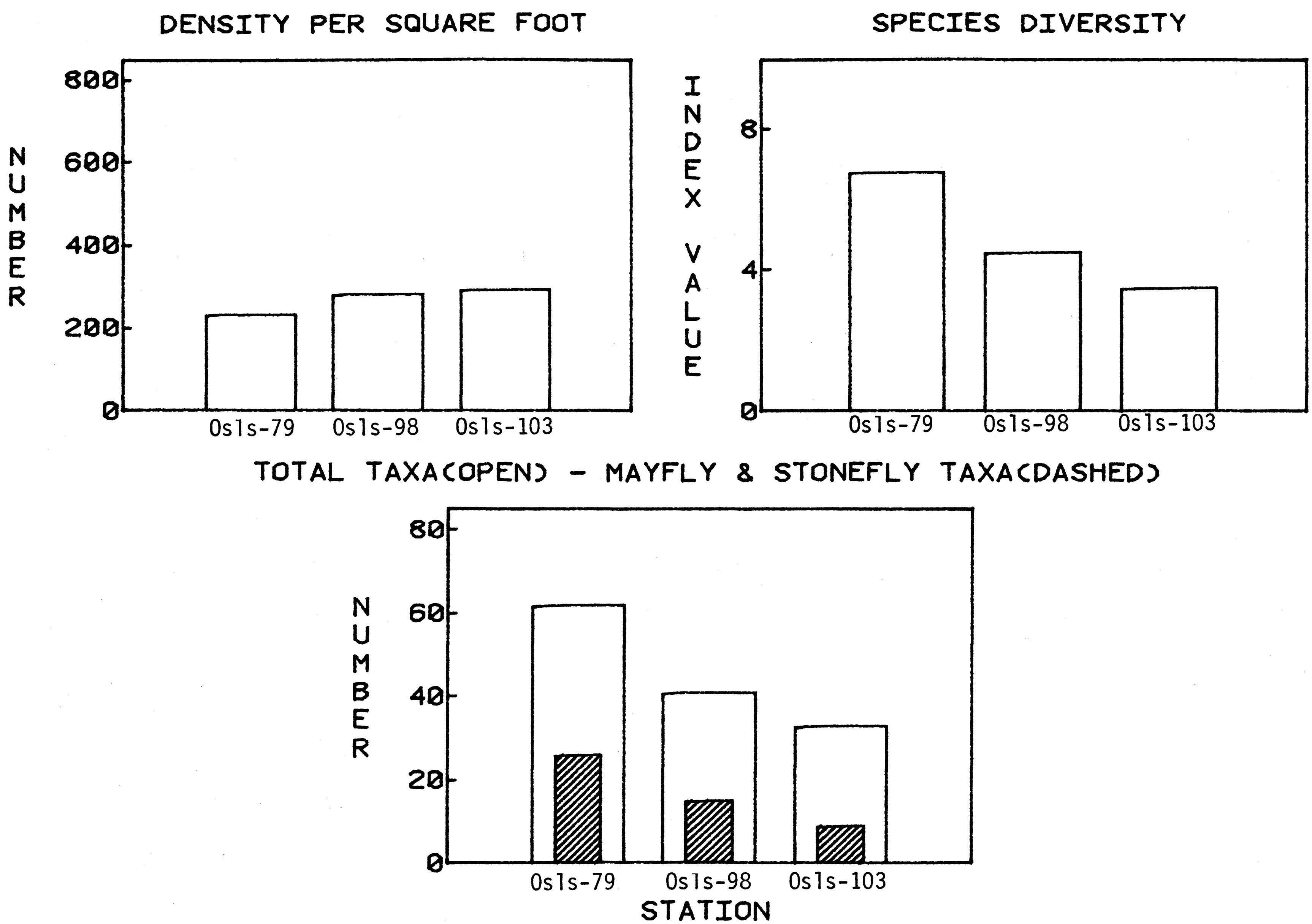


FIGURE 32. BENTHIC INVERTEBRATE COMMUNITY CHARACTERISTICS FOR SAMPLES FROM THE MAINSTEM LITTLE SAC RIVER- 1975-76.

(Appendix Table A-17, Table 3). Tolerant taxa made up the vast majority of the benthos community at Osls-103 (Fig. 33). Ninety-two percent of all invertebrates collected at this site were midges and aquatic earthworms. Other taxa present in larger numbers were:

Flies (61%)		Other (34%)		Mayflies (3%)	
Chironomidae	96%	Oligochaeta	97%	_Baetis_ sp.	86%
Simuliidae	3%	_Crangonyx minor_	<1%	_Caenis_ sp.	7%
Empididae	<1%	Planariidae	<1%	_Stenonema femoratum_	3%

Physical and biological features in this portion of the Little Sac River suggest severely enriched and degraded conditions, similar to those found in streams suffering from heavy organic pollution. Such sources of pollution were not evident upstream from this site. It is possible for low level discharges from an impoundment to cause such conditions, however, the discharge from McDaniel Lake was over the spillway and should be good quality water.

Cluster analysis and coefficients of similarity linked the communities at ten stations with the community at Osls-103. Most of these sites received heavy organic loading in their watersheds and supported large numbers of midges and aquatic earthworms.

Considering all the data collected at this site, water quality was classified as polluted but the source(s) of pollution are unknown at this time. Further investigation into this degradation is warranted.

The next sample site, Osls-98, was located 5 miles downstream from Osls-103 and about 4.5 miles below the confluence with the South Dry Sac River (Fig. 4, Table 2). This tributary receives treated sewage effluent

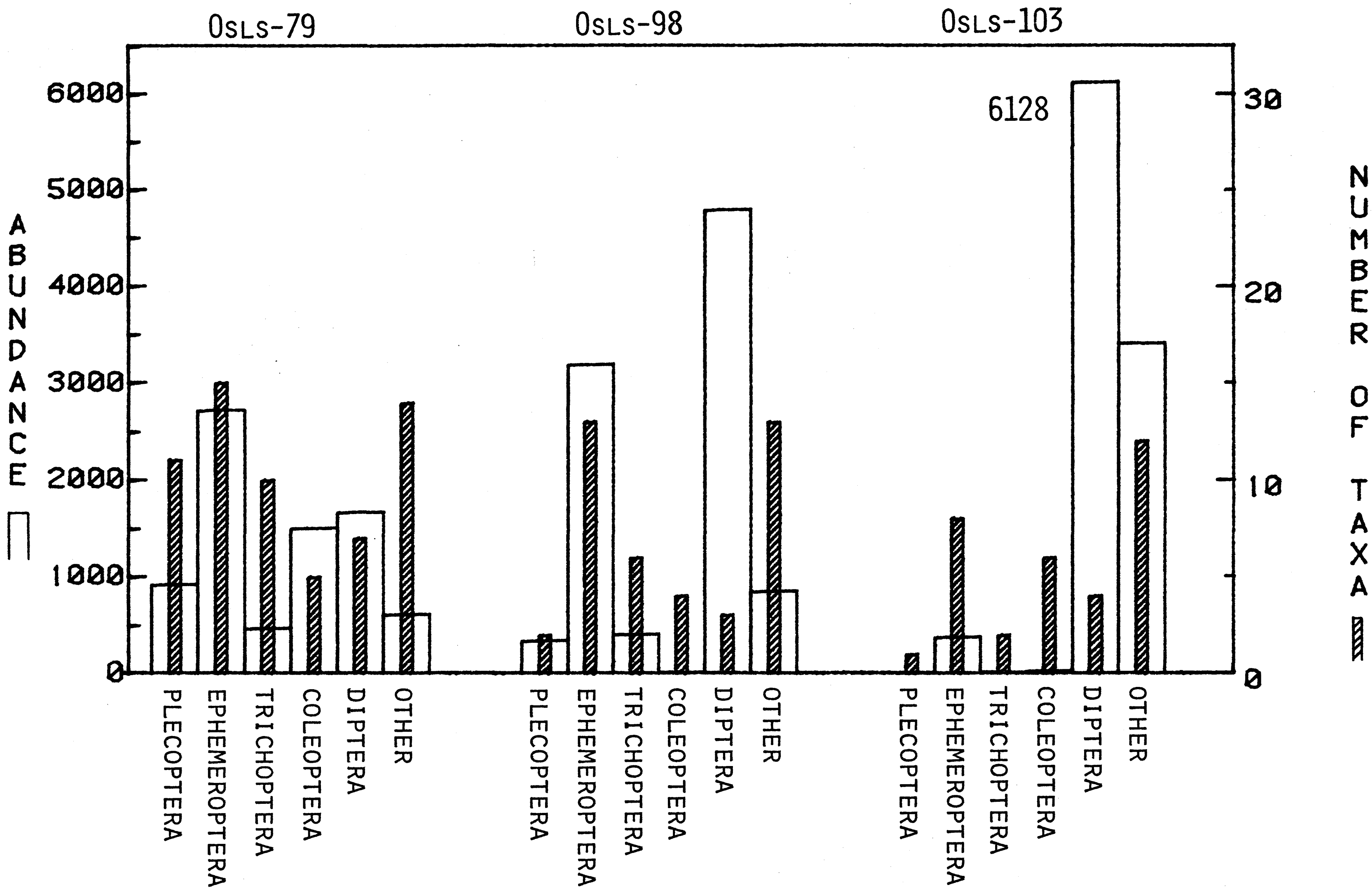


FIGURE 33. COMMUNITY STRUCTURE OF BENTHIC INVERTEBRATES BY ABUNDANCE AND TAXA FOR SAMPLES FROM THE MAINSTEM LITTLE SAC RIVER- 1975-76.

from two small lagoons (total P.E.=298) and the northwest Springfield sewage treatment plant (P.E.=35,000) (Table 1). The northwest plant is an activated sludge plant and has been severely overloaded for sometime. Problems with this facility have been documented as far back as 1971. Benthos samples were collected in 1971 at Highway 13, 4 miles upstream from Osls-98. These samples consisted primarily of midges and aquatic earthworms and were quite low in species diversity and numbers of sensitive taxa. Over 20% of the riffle was covered with filamentous algae and sewage fungus (*Sphaerotilis natans*). Water quality in 1971 was considered severely polluted (Ryck 1973c). A fish kill in 1977 was documented in the South Dry Sac River downstream from this facility. A bypass of raw sewage killed an estimated 1,400 fish, mostly carp, *Cyprinus carpio*, in one mile of stream (Czarnezki 1978). The 1978 water pollution survey listed 2 miles of the South Dry Sac River as grossly polluted. Four and one half miles of the Little Sac River were classified polluted, including site Osls-98. The remaining lower 26 miles of the Little Sac River was considered moderately polluted primarily because of excessive nutrients. These nutrients resulted in periodic heavy algae growths in this reach (Missouri Department of Conservation 1978). Benthos samples for the present survey were collected from Osls-98, located 4 miles downstream from the 1971 site (Fig. 4, Table 2). These samples were collected from a stable riffle which consisted of limestone fragments varying in size from sand to rock and rubble. Larger fragments made up a major portion of this substrate. Periphyton and filamentous algae growths were heavy at times, primarily through the winter and spring. Water clarity was generally clear and temperatures were moderate. Surrounding land uses were primarily pastureland with moderate amounts of woodland. The effects of excessive nutrients were visible at this site

in the form of aquatic plant growths but not to extent noted in 1971, 4 miles upstream.

Invertebrate density was almost identical to that at Osls-103, averaging 282 organisms per square foot (Appendix Table A-17). Community characteristics, however, had improved over those at Osls-103 and those apparently present at Highway 13 in 1971 (Fig. 32). Community structure had also improved (Fig. 33), along with an increase in the number of pollution sensitive taxa. Benthic invertebrate community characteristics consistently fell in the middle to upper moderately polluted range. These apparent improvements over 1971 were the reason for classifying the water quality at Osls-98 moderately polluted during 1975-76. Improvements in the northwest treatment plant would undoubtedly improve the habitat and water quality in this reach.

The benthos community at Osls-98 was similar to nine other sites (Appendix Table A-23) and clustered with seven sites dominated by blackflies (Appendix Table A-24). Most of these sites (63 percent) were on prairie streams. Dominant taxa included:

Flies (50%)		Mayflies (33%)		Other (9%)	
Simuliidae	52%	*Baetis* sp.	36%	Oligochaeta	63%
Chironomidae	47%	*Stenacron interpunctatum*	30%	*Gammarus pseudolimnaeus*	12%
Empididae	1%	*Caenis* sp.	26%	Planariidae	9%
		Stenonema femoratum	6%		

Some benthos such as blackflies, *Baetis* sp., *Gammarus pseudolimnaeus*, and Planarians were collected in higher than normal numbers. This suggests

some influence of ground water from springs in this reach since these benthic types have also been found in large numbers in other streams influenced by springs (Duchrow 1977).

Although the North Dry Sac River was not sampled during this survey, the importance of this small stream is worth mentioning at this point. Good water quality must be maintained in it and surrounding streams because the lower 3 miles of the North Dry Sac River near Pleasant Hope, Missouri supports a population of Niangua darter (Pflieger 1978). The value of this threatened species has been discussed previously.

The North Dry Sac River joins the Little Sac River about 5 miles upstream from site Osls-79. This sampling site was located downstream from a low water crossing in Polk County, about 8 miles above the upper limits of Stockton Reservoir (Fig. 4, Table 2). The permanent riffle at this site consisted of limestone rocks which varied greatly in size and shape. This substrate was quite stable and provided a good habitat for benthos production. The watershed in this reach was much like that further upstream, consisting primarily of wooded areas and permanent pasture. Water clarity was clear during normal flow and temperatures were moderate. Algae and periphyton growths were heavy during much of the year. These growths were caused by excessive nutrients entering the Little Sac River from upstream pollution sources discussed previously. The only additional discharge entering the Little Sac River between Osls-79 and Osls-98 was from one small lagoon (P.E.=72) which entered a tributary (Table 1). This discharge was felt to have a negligible impact on the water quality of the Little Sac River in relation to the previous discharges. The potential of leachate entering the Little Sac River does exist from the sanitary landfill serving Springfield, Missouri (Table 1). The landfill site is located about 9 miles upstream from Osls-79.

Invertebrate density at Osls-79 was moderate, averaging 232 organisms per square foot. This was only slightly lower than at the previous two sites on the Little Sac River (Fig. 32). Community characteristics were high, exceeding minimum criteria for unpolluted water quality on a seasonal and annual basis (Appendix Table A-17, Table 3). Water quality in this reach was therefore classified unpolluted based on these biological characteristics. Physical evidence does show that this reach receives an excessive amount of nutrients. These nutrients have resulted in dense growths of filamentous algae. To date, these nutrients appear to be positively affecting the invertebrates in this segment by increasing productivity. If the point sources identified during this survey are not abated, this enhancement will eventually change to degradation. Considering the potential problem with excessive nutrients and the constant threat of degradation, the 26 miles of the Little Sac River upstream from Stockton were considered moderately polluted in 1978 until the problems in the upper watershed are resolved (Missouri Department of Conservation 1978).

The benthos community at Osls-79 was similar to 13 other sites, all being on Ozark (69%) or intergrade streams. All these streams had water quality classified as unpolluted (Appendix Table A-23). This site clustered with four of the similar sites and four others, all having communities dominated by mayflies, midges, and beetles (Appendix Table A-24). The bar graphs in Figure 33 depict the increase in pollution sensitive taxa in the Little Sac River as the distance from the major pollution sources increases. Sensitive taxa were well represented in the samples from Osls-79 and consisted of the following:

Mayflies (34%)		Flies (21%)		Beetles (19%)	
Tricorythodes sp.	30%	Chironomidae	67%	Stenelmis sp.	81%
Stenonema mediopunctatum	14%	Bezzia, Probezzia, ...,	19%	Psephenus herricki	16%
Baetis sp.	13%	Simuliidae	11%	Optioservus sandersoni	1%
Pseudocloeon sp.	11%				

Stoneflies (11%)	
Perlesta placida	30%
Neoperla clymene	15%
Amphinemura/ Prostoia	13%

The Little Sac River, like the mainstem Sac River is an intergrade stream between the Ozarks and prairie streams. The physical habitat and biological structure of invertebrate communities, however, have taken on the appearance and characteristics of those in Ozark streams. A good illustration of this was the similarities between the communities at the three sites on the Little Sac River. Fifty percent of these similar sites were on Ozark streams. Only 25% of the similarities were with prairie streams. Most of these were in the South Grand River Basin.

Point source pollution impacted the Little Sac River downstream from Springfield, Missouri, however, the major impact was the permanent inundation of the lower 35% by Stockton Reservoir. All totaled, reservoir construction and pollution have altered approximately 87% of the original mainstem river mileage of the Little Sac River. Abatement of point source pollution problems could allow almost half of this mileage to recover.

Clear Creek

Clear Creek flows across the northwestern portion of Greene County, between the watersheds of the Sac and Little Sac rivers. It begins at Elwood, Missouri, located at the west central city limits of Springfield and flows northwest for about 20 miles before joining the Sac River (Fig. 4). The watershed was similar to the previous streams consisting of permanent pasture and woodlands. Vineyard and Feder (1974) list 12 small springs within Clear Creek's watershed. Benthic invertebrate samples were collected at a permanent riffle site (Oscl-1) located about 1 mile upstream from its confluence with the Sac River (Fig. 4, Table 2). The riffle was made up of limestone materials which varied greatly in size and shape. Two small sewage treatment lagoons (P.E.=142 and 240) discharge directly to Clear Creek (Table 1). These discharges seemed to have no degrading effects upon the water quality in Clear Creek. Water clarity was clear during normal flow. Temperatures were moderate and did not appear to be influenced by ground water discharges from springs. Periphyton growths were not excessive and benthic invertebrate community characteristics were consistently high and exceeded minimum criteria for unpolluted Missouri streams (Fig. 34, Appendix Table A-17, Table 3). Density was considered moderate, averaging 239 organisms per square foot.

The benthos community at Oscl-1 clustered with eight other sites which were classified unpolluted (Appendix Table A-24). These sites included Os-82, Os-86, and Osls-79. Nineteen sites in the Osage River Basin had similar coefficients of similarity with the benthos community in Clear Creek (Appendix Table A-23). Forty-two percent of these sites were on Ozark streams, 37% on intergrade streams in the Sac River Basin and the remainder on prairie sites.

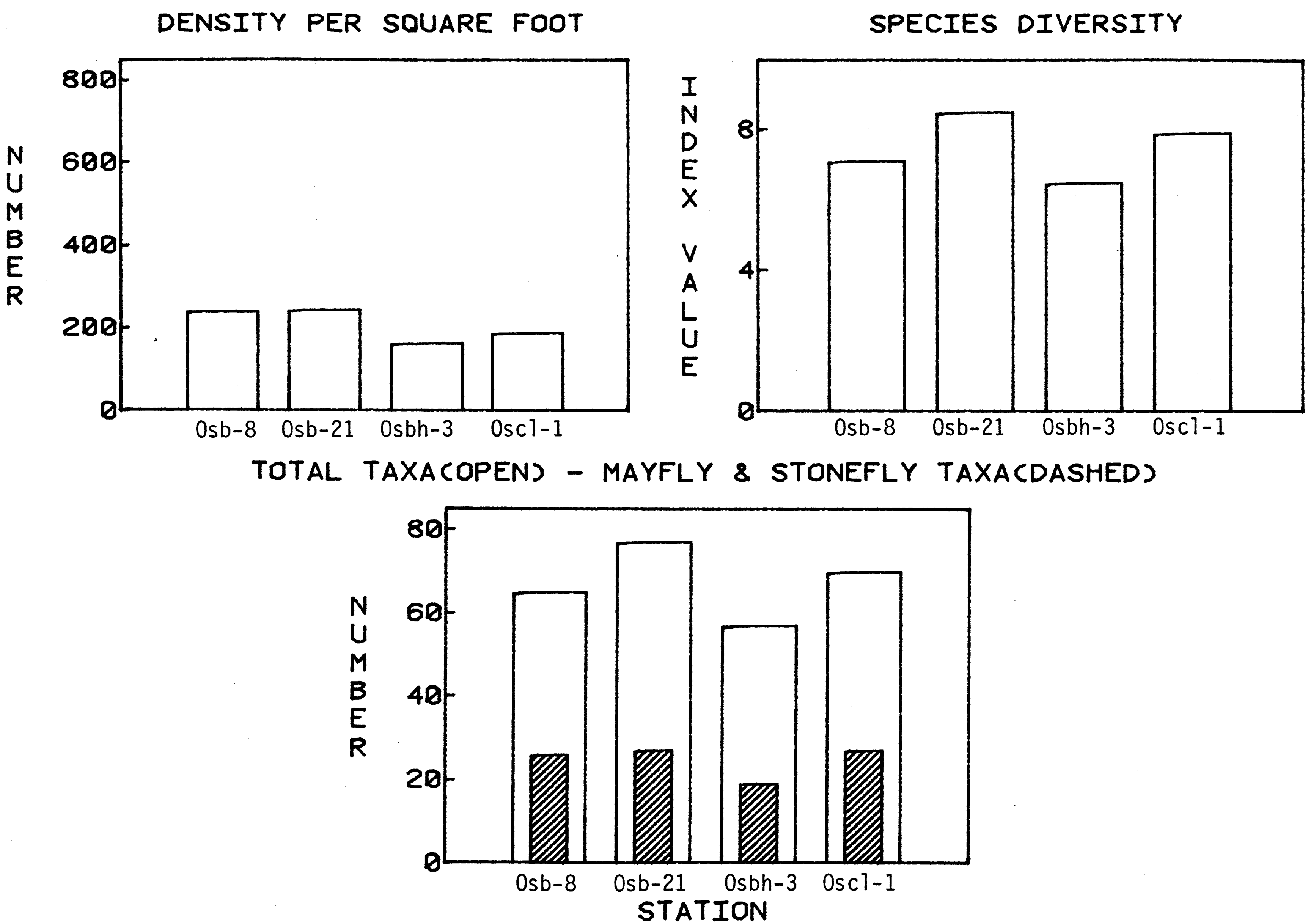


FIGURE 34. BENTHIC INVERTEBRATE COMMUNITY CHARACTERISTICS FOR SAMPLES FROM WEST FLOWING INTERGRADE TRIBUTARIES OF THE SAC RIVER- 1975-76.

Water quality in Clear Creek was classified unpolluted and has not been affected by man's alterations. The diverse, pollution sensitive invertebrate community at Oscl-1 verifies this status (Fig. 35). Dominant taxa in this community consisted of the following:

Flies (40%)		Mayflies (22%)		Beetles (20%)	
Chironomidae	74%	*Stenonema mediopunctatum*	23%	*Stenelmis* sp.	57%
Simuliidae	15%	*Heptagenia* sp.	17%	*Optioservus sandersoni*	41%
Bezzia, *Probezzia*, ...,	7%	*S. pulchellum*	14%	*Psephenus herricki*	1%
		Baetis sp.	11%		

Stoneflies (7%)	
Allocapnia sp.	53%
Isoperla sp.	27%
Perlesta placida	9%

Bear Creek

This intergrade stream originates in central Polk County near Bolivar, Missouri. Bear Creek flows west through woodlands and permanent pasture for about 35 miles before joining the Sac River about 1.5 miles downstream from Stockton Dam. It receives treated sewage effluent from one small private lagoon (P.E.=61), two lagoons serving Fairplay, Missouri (1.4 and 0.6 acres) and a cattle feedlot (Table 1). All discharges enter in the upper 50% of the watershed.

The aquatic habitat in Bear Creek was much like that in Clear Creek (Oscl-1). Two sampling sites were established on Bear Creek. The upper most site (Osb-21) was in the headwaters and received drainage from the

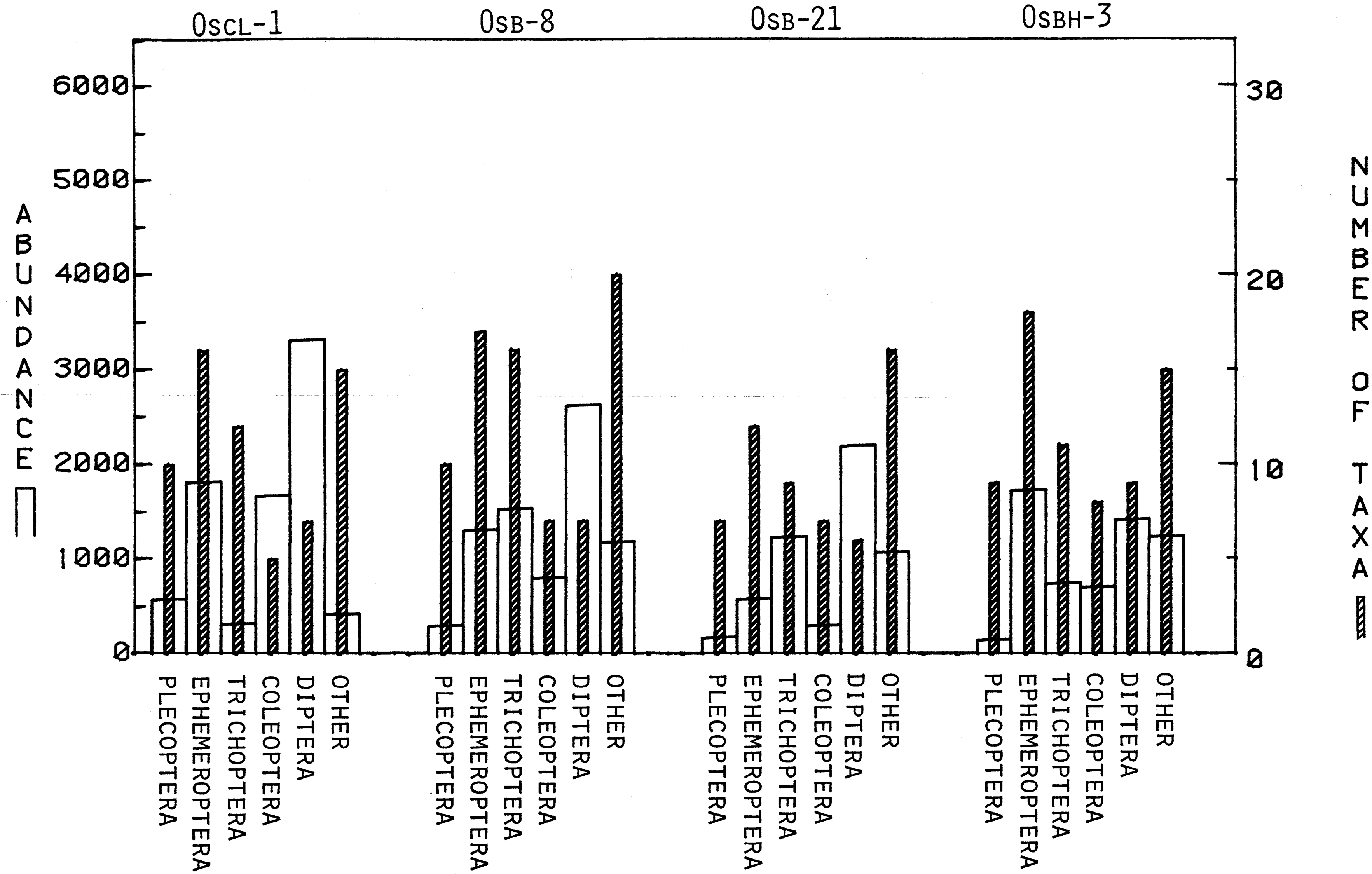


FIGURE 35. COMMUNITY STRUCTURE OF BENTHIC INVERTEBRATES BY ABUNDANCE AND TAXA FOR SAMPLES FROM WEST FLOWING INTERGRADE TRIBUTARIES OF THE SAC RIVER- 1975-76.

private lagoon and feedlot. The lower site (Osb-8) was in Cedar County and received the discharges from the lagoons at Fair Play, about 11 miles upstream from the sample site (Fig. 4, Table 1 and 2). Substrate at both sites resembled that of an Ozark stream, consisting of limestone fragments which varied widely in size and shape. During normal flow, water clarity was clear, temperatures were moderate, and periphyton growths were not excessive. All benthic invertebrate community characteristics at the lower site (Osb-8) exceeded minimum criteria for unpolluted streams (Appendix Table A-17, Table 3). In contrast, these characteristics were not as high at Osb-21 (Fig. 34). They did not consistently exceed minimum criteria for unpolluted Missouri streams (Appendix Table A-17, Table 3). However, the communities at both sites consisted of a wide variety of taxa, many being intolerant of pollution (Fig. 35). Water quality at both sites was classified as unpolluted at the time of the survey, however, the upper site (Osb-21) may be under some stress, possibly from non-point sources undetected during the study. The benthos community at Osb-8 was exceptionally diverse having annual values for total taxa and species diversity ranking second highest in the Osage River Basin. Invertebrate sample density at the sample sites was considered moderate, averaging 242 organisms per square foot at Osb-8 and 163 at Osb-21. The most abundant taxa at these sites were as follows:

Osb-8

Flies (34%)		Caddisflies (20%)		Mayflies (17%)	
Chironomidae	78%	*Cheumatopsyche* sp.	81%	*Stenonema pulchellum*	29%
Simuliidae	12%	*Chimarra obscura*	8%	*S. femoratum*	12%
Bezzia/ Probezzia, ...,	5%	*Rhyacophila* sp.	2%	*Stenacron interpunctatum*	11%
				Isonychia sp.	11%
				Caenis sp.	10%

Other (15%)	
Oligochaeta	39%
Goniobasis sp.	27%
Sphaeriidae	11%

Osb-21

Flies (39%)		Caddisflies (22%)		Other (19%)	
Chironomidae	52%	*Cheumatopsyche* sp.	64%	Oligochaeta	54%
Simuliidae	45%	*Ochrotrichia* sp.	28%	Sphaeriidae	15%
Bezzia/ Probezzia, ...,	1%	*Helicopsyche borealis*	3%	Planariidae	15%
				Goniobasis sp.	8%

Mayflies (10%)	
Baetis sp.	52%
Pseudocloeon sp.	21%
Stenonema femoratum	12%

As mentioned previously, the benthos communities at these two sites on Bear Creek were quite diverse and consisted of many different taxa. The

community in lower Bear Creek (Osb-8) was the most cosmopolitan of the communities at the 85 sites in the Osage River Basin. This community was similar to almost half (35) of the communities sampled (Appendix Table A-23). Of these communities, 37% of the sites were on Ozark streams, 37% were on prairie streams and the remainder were sites within the Sac River Basin. The community at Osb-8 was most similar to the community in Turkey Creek (Ot-5), a minor mainstem tributary to the Osage River (C=69). This community (Osb-8) clustered with the group of 18 sites with midge, mayfly, caddisfly dominant communities (Appendix Table A-24). Most of the communities in this cluster were from unpolluted Ozark streams.

The community inhabiting the upper portion of Bear Creek (Osb-21) was not as cosmospolitan as the previous community. Its community was similar to those at 25 sites. Many of these sites were on Ozark streams (44%). The community in upper Bear Creek clustered with medium density communities dominated by caddisflies, midges and mayflies. This community (Osb-21) was most closely aligned with that in lower Horse Creek (Osch-14) which will be discussed later.

Brush Creek

Six miles of Brush Creek are known to contain a thriving population of the threatened Niangua darter. According to Pflieger (1978), the reach which contains this population extends between 3 and 8 miles above its confluence with the Sac River. Brush Creek begins in Polk County, just south of Humansville, Missouri. It flows a total of 23 miles across the Springfield Plain Region before entering the Sac River near Blackjack, Missouri (Fig. 4). This stream was sampled 3 miles upstream from its mouth at a permanent riffle located above a low water crossing (Fig. 4, Table 2). Brush Creek at this point (Osbh-3) resembled an Ozark stream. Water clarity was normally clear

and temperatures were moderate. Riffle substrate was stable and consisted of limestone which varied greatly in size and shape. Periphyton growths were not excessive but increased significantly during the spring 1976 sampling period.

Treated sewage effluent from a severely overloaded lagoon serving Humansville discharges into the headwaters of Brush Creek (Table 1). This discharge enters Brush Creek approximately at river mile 18. In 1978, the effects of this discharge seriously degraded 1.5 miles of Brush Creek. An additional 8.5 miles were moderately polluted from the effects of excessive nutrients (Missouri Department of Conservation 1978). One small fish kill has been documented in Bear Creek and was attributed to this lagoon effluent. The kill occurred in 1976 and affected less than 1 mile of stream (Robinson-Wilson 1977). Since the completion of Truman Reservoir, the lower 3 miles of Brush Creek are within its flood pool elevation.

Water quality in Brush Creek during 1975-76 was quite good. Average invertebrate density was moderate. Community characteristics were consistently high and exceeded minimum criteria for unpolluted Missouri streams (Appendix Table A-17, Table 3). The invertebrate community at Osbh-3 was very diverse and consisted of numerous pollution sensitive taxa (Fig. 35). Water quality in this reach was therefore classified unpolluted, however, the threat of periodic flooding from below and pollution from upstream makes this status tenuous.

The benthos community at Osbh-3 was similar to 14 other communities, primarily on Ozark type streams (71%). Most of these communities were within stream reaches that were unaffected by man's activities (Appendix Table A-23). The benthos community in Brush Creek consisted of a variety of taxa which caused it to cluster with only one other site in the Osage River Basin

(Appendix Table A-24). This site was on Monegaw Creek (Omg-7) and the alignment was not extremely strong. The community at Osbh-3 consisted of the following taxa:

Mayflies (29%)		Flies (24%)		Other (21%)	
Caenis sp.	27%	Chironomidae	87%	Oligochaeta	43%
Stenonema pulchellum	25%	Simuliidae	5%	Sphaeriidae	36%
Tricorythodes sp.	18%	_Bezzia/Probezzia_, ...,	4%	_Ferrissia_ sp.	14%
Stenacron interpunctatum	9%				

Caddisflies (12%)	
Hydroptila sp.	27%
Cheumatopsyche sp.	20%
Neophylax sp.	14%
Chimarra obscura	11%
Helicopsyche borealis	9%

Reservoir construction and pollution in Brush Creek have affected 56% of this stream. This severely threatens the future of the Niangua darter population which exists in the unpolluted reach that is sandwiched between a fluctuating reservoir and organic pollution. Drastic upgrading or eliminating the effluent from the Humansville facility would improve the darter's chances of survival.

Turnback Creek

Turnback Creek is an intergrade stream which flows across the heart of the Springfield Plain Region (Fig. 0). This stream originates in eastern Lawrence County and flows north for about 46 miles before joining the Sac

River near Greenfield, Missouri (Fig. 4). The completion of Stockton Reservoir in 1969 permanently inundated the lower 4 miles of Turnback Creek and placed another 5 miles within its floodpool. This accounts for 20% of the original mileage.

Turnback Creek is a moderate sized stream, comparable to the Little Sac and Maries rivers. Its watershed at Greenfield, Missouri covers approximately 252 square miles and the average discharge over 15 years of record was 240 cubic feet per second (U.S. Geological Survey 1980). The sampling site on Turnback Creek (Ost-6) was located just east of Greenfield at the Dade County Highway O crossing (Fig. 4, Table 2). Aquatic habitat at this site was much like that at previous sites, having more Ozark stream characteristics than prairie. Five moderately sized springs (collective discharges averaging 2,350,000 gallons per day) discharge into headwater reaches of Turnback Creek in eastern Lawrence County (Vineyard and Feder 1974).

Substrate consisted of a high percentage of larger rock and rubble sized limestone fragments. This substrate was quite stable and afforded good habitat for benthic invertebrate production. Water clarity was mostly clear and temperatures were moderate. Periphyton and algae growths were at times dense but generally not excessive. One of the three sewage treatment lagoons which serve Greenfield discharges to a tributary of Turnback Creek upstream from Ost-6 (Table 1). Although a source of nutrients, this discharge has not caused any apparent problems in Turnback Creek. Invertebrate density was moderately low, averaging 115 organisms per square foot (Fig. 36). Benthic invertebrate community characteristics consistently exceeded minimum criteria for unpolluted Missouri streams (Appendix Table A-17, Table 3). Water quality was quite good and was classified unpolluted according to these criteria. The diverse assemblage of pollution sensitive

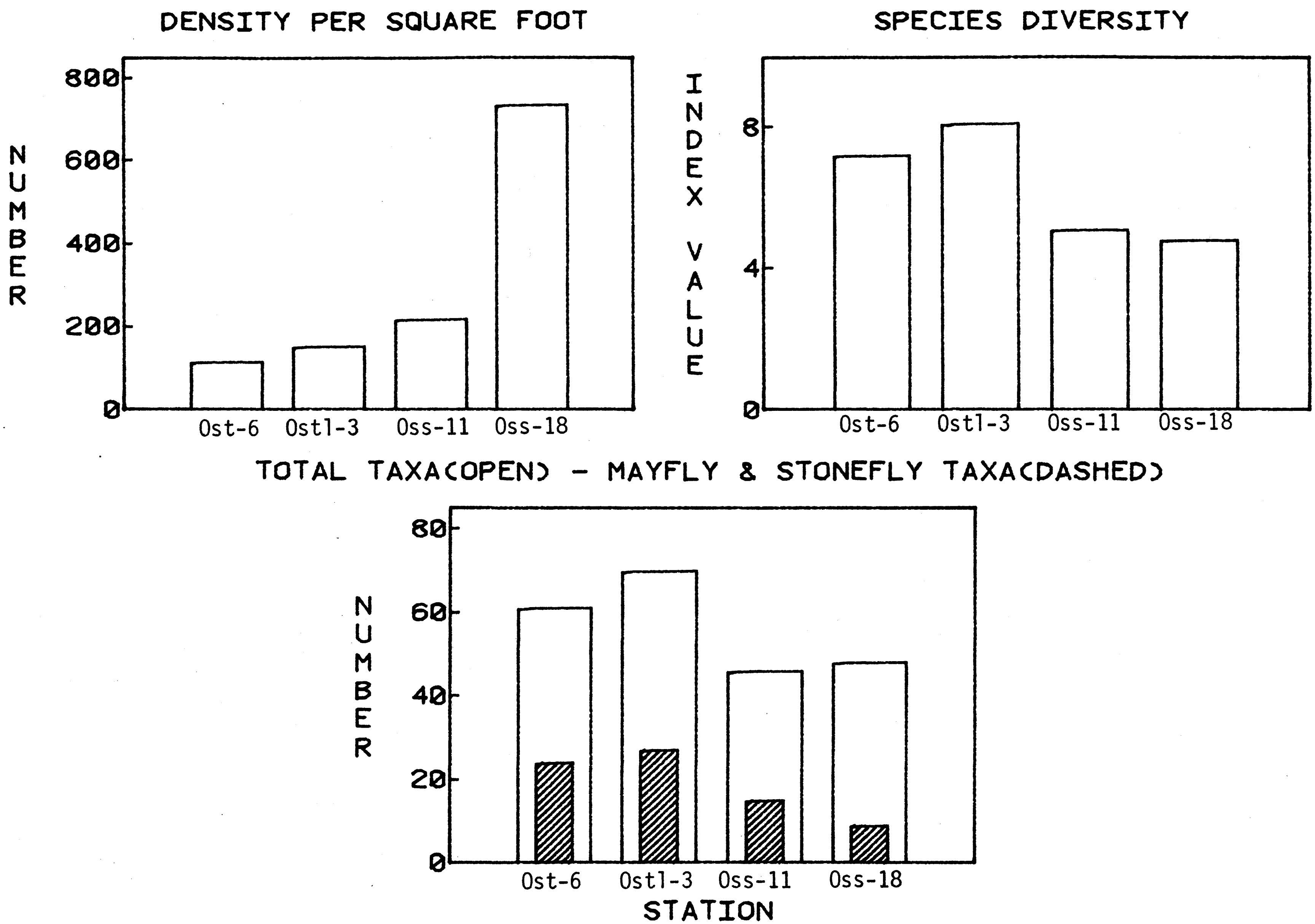


FIGURE 36. BENTHIC INVERTEBRATE COMMUNITY CHARACTERISTICS FOR SAMPLES FROM EAST FLOWING INTERGRADE TRIBUTARIES OF THE SAC RIVER- 1975-76.

taxa support this status (Fig. 37). Dominant taxa at Ost-6 consisted of the following groups:

Flies (44%)		Mayflies (34%)		Caddisflies (7%)	
Chironomidae	85%	*Stenonema mediopunctatum*	25%	*Symphytopsyche bifida*	27%
Simuliidae	13%	*Ephemerella needhami*	20%	*Cheumatopsyche* sp.	25%
Bezzia/ Probezzia, ...,	41%	*S. pulchellum*	13%	*Agapetus* sp.	25%
		Isonychia sp.	7%	*Ochrotrichia* sp.	13%

The community in Turnback Creek was similar to those at 18 other sites, most inhabiting Ozark and intergrade streams (Appendix Table A-23). Cluster analysis included the Turnback Creek community with 17 communities, most coming from Ozark streams and all having midge-caddisfly-mayfly communities (Appendix Table A-24).

Limestone Creek

Limestone Creek, a major tributary, enters Turnback Creek one mile upstream from Ost-6. It originates in southern Dade County and flows north for 16 miles before joining Turnback Creek. The benthos samples were collected from a stable, permanent limestone riffle (Ostl-3) near the south edge of Greenfield, Missouri (Fig. 4, Table 2). The substrate consisted of a diverse mixture of limestone and chert, closely resembling the substrate in a true Ozark stream. Water in Limestone Creek was always clear, attesting to the quality of its watershed. Temperatures were moderate and periphyton growths were not excessive. One small spring, Honey Creek Spring, enters Limestone Creek at Pennsboro, Missouri near the headwaters (Vineyard and

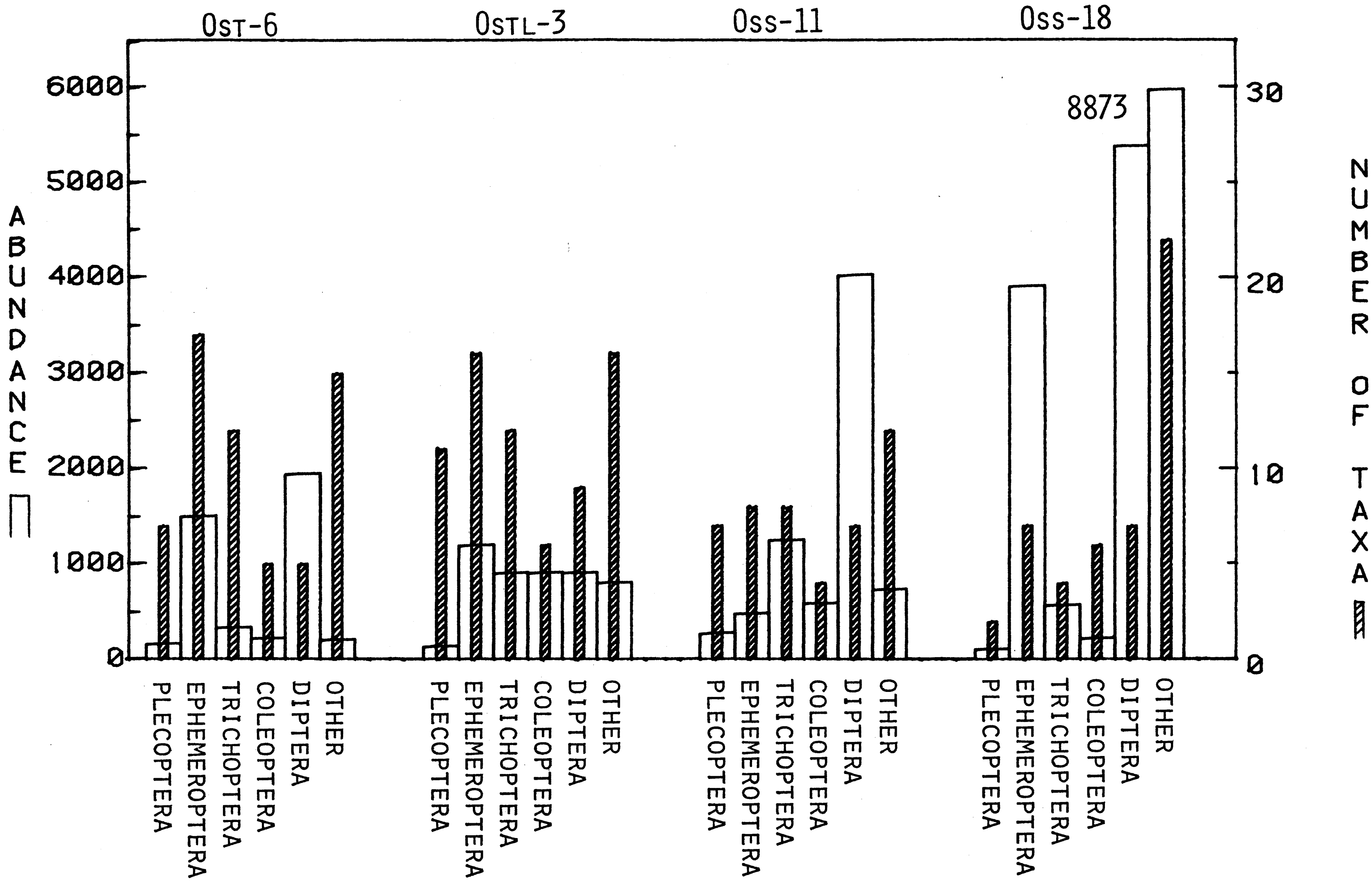


FIGURE 37. COMMUNITY STRUCTURE OF BENTHIC INVERTEBRATES BY ABUNDANCE AND TAXA FOR SAMPLES FROM EAST FLOWING INTERGRADE TRIBUTARIES OF THE SAC RIVER- 1975-76.

Feder 1974). Pollution problems consisted of a limestone quarry and one large dairy operation which has moderately polluted 2 miles of a small tributary (Missouri Department of Conservation 1978). In addition, the lower mile of Limestone Creek is within the flood pool of Stockton Reservoir. Water quality in Limestone Creek was quite good and was classified unpolluted. Community characteristics for samples collected from Ostl-3 were high and consistently above minimum criteria on a seasonal and annual basis (Fig. 36, Appendix Table A-17, Table 3). Average invertebrate density was moderate and the community consisted of numerous pollution sensitive taxa (Fig. 37). This community clustered with eight other communities inhabiting selected sites on the Sac, Niangua, and Pomme de Terre rivers (Appendix Table A-24). The benthos community at Ostl-3 was similar with 11 sites, most being within these three river basins (Appendix Table A-23). The benthos community at Ostl-3 aligned closest to that inhabiting the upper Sac River at Os-86 (C=68) and consisted of the following taxa:

Mayflies (24%)		Caddisflies (18%)		Flies (18%)	
Stenonema pulchellum	42%	*Agapetus* sp.	57%	Chironomidae	75%
Caenis sp.	17%	*Cheumatopsyche* sp.	27%	*Bezzia/Probezzia*, ...,	10%
Baetis sp.	12%	*Helicopsyche borealis*	4%	Empididae	6%
Isonychia sp.	10%				
Heptagenia sp.	10%				

Beetles (18%)	
Optioservus sandersoni	79%
Stenelmis sp.	11%
Psephenus herricki	8%

Sons Creek

Forty eight percent of the original mileage of Sons Creek is under the influence of Stockton Reservoir. Eleven miles (38%) have been permanently covered and the other 10% (3 miles) are within flood pool elevation. The only potential point source of pollution identified during the survey was a limestone quarry located in the headwaters (Table 1). Originally, Sons Creek was 29 miles long, beginning in southwestern Dade County. It flowed north and joined the Sac River east of Arcola, Missouri. Sons Creek was sampled at two sites, both located in the upper reach not influenced by the reservoir. The uppermost site (Oss-18) was located at the Highway 160 crossing, east of Lockwood, Missouri. The lower site (Oss-11) was about 7 miles downstream (Fig. 4, Table 2). Benthos samples at both sites were collected from permanent stable riffles each consisting of a variety of limestone fragments. Sons Creek for the most part was clear, maintained moderate temperatures and supported heavier than normal growths of filamentous algae. Algal growths were especially heavy at Oss-18 on upper Sons Creek, indicating heavy nutrient inputs into its headwaters. The lack of point sources would tend to implicate non-point runoff. In addition to algae, water willow was also quite prevalent at the lower sample site (Oss-11).

Water quality in Sons Creek was classified moderately polluted at both sites, primarily because benthic invertebrate community characteristics consistently fell within this range (Fig. 36, Appendix Table A-17, Table 3). Most characteristics for samples collected at the two sites varied little from each other on a seasonal or annual basis (Appendix Table A-17). The exception to this was density. Density in lower Sons Creek at Oss-11 was considered moderate averaging 217 organisms per square foot whereas the

average density at Oss-18 was extremely high. The average of 734 organisms per square foot at Oss-18 was the second highest recorded in the Osage River Basin. The headwaters of Horse Creek, which were only a few miles west of Oss-18, had the highest average. Although the differences between most community characteristics at these two sites on Sons Creek were slight, the aquatic habitat in the headwaters of Sons Creek appeared much more degraded. Larger quantities of fine silts were in the substrate and conditions appeared more enriched. The community at Oss-18 also consisted of a larger proportion of tolerant taxa (Fig. 37) and did not resemble the community inhabiting downstream reaches (C=34). In fact, the community at Oss-18 did not cluster with any other community in the Osage River Basin. This community consisted largely of the following:

Others (46%)		Flies (28%)		Mayflies (20%)	
Oligochaeta	52%	Chironomidae	90%	*Caenis* sp.	87%
Sphaeriidae	16%	Simuliidae	7%	*Baetis* sp.	6%
Physa sp.	11%	*Bezzia*/*Probezzia*, ...,	1%	*Stenonema femoratum*	4%

Caddisflies (3%)	
Ochrotrichia sp.	55%
Cheumatopsyche sp.	35%
Rhyacophila sp.	8%

Habitat at Oss-11 did not have as much fine material in the substrate and appeared less enriched. Although many taxa at Oss-11 were also found at Oss-18, the preponderance of more pollution sensitive taxa in the lower reaches suggested less degradation. The community in lower Sons Creek (Oss-11) was

similar to 18 other sites and clustered with many of these (Appendix Tables A-23 and A-24). These 18 sites were equally distributed between the prairie, intergrade and Ozark regions of the Osage River Basin. Dominant taxa at Oss-11 consisted of the following:

Flies (54%)		Caddisflies (17%)		Other (10%)	
Chironomidae	68%	*Ochrotrichia* sp.	54%	Oligochaeta	69%
Simuliidae	25%	*Cheumatopsyche* sp.	23%	Planorbidae	7%
Bezzia/*Probezzia*, ...,	4%	*Rhyacophila* sp.	13%	Sphaeriidae	7%

Although the sources of the degradation in the Sons Creek Watershed were not positively identified during this survey, they were probably non-point in origin and agricultural in nature. The preponderance of pasture and livestock raising activities in this area are a likely contributing factor.

Cedar Creek

Cedar Creek begins in west-central Dade County and flows north for about 53 miles before joining the Sac River in northern Cedar County. The upper two-thirds of Cedar Creek flow across the Springfield Plain Region while the lower portion borders the Cherokee Plains Region (Fig. 0). This intergrade stream was moderate in size, being comparable to Maries River, Turnback Creek and the Little Sac River. At a U.S. Geological Survey gaging station located about 4 miles from its mouth, Cedar Creek drains about 420 square miles and has had an average discharge of 293 cubic feet per second over a 35 year timespan (U.S. Geological Survey 1980). Water in Cedar Creek was generally clear, temperatures moderate and periphyton growths were not excessive.

Two sites were sampled. The lower site (Osc-1) was 1 mile upstream from its mouth (Fig. 4, Table 2). Substrate at this site consisted of limestone fragments of varying sizes that formed a stable riffle. The habitat at Osc-1, however, varied from that at the upper site, located 19 miles upstream (Fig. 4, Table 2). Limestone fragments also constituted the riffle at Osc-20, however, larger, angular sizes were much more numerous than at Osc-1.

Point pollution discharges entering Cedar Creek were limited to a few discharges from small sewage treatment facilities. One (P.E.=32) discharging into a tributary upstream from Osc-20 and two others (P.E.=141) entering tributaries above Osc-1 (Table 1). The only other alteration affecting lower Cedar Creek occurred in 1978 with the completion of Truman Dam and Reservoir which placed the lower 12 miles within its flood pool, subjecting this reach to periodic inundation. This change has altered approximately 23% of Cedar Creek's original mileage.

Benthic invertebrate standing crop in Cedar Creek as indicated by average densities appeared to be less than most of the previously discussed intergrade streams (Appendix Table A-17). Average densities at Osc-20 were light, averaging 94 organisms per square foot. Densities at Osc-1 were even less (Fig. 38, Appendix Table A-17). Benthic invertebrate community characteristics followed this same trend. Characteristics for samples collected at Osc-20 were higher than those at Osc-1 (Fig. 38) and exceeded minimum criteria for unpolluted Missouri streams (Appendix Table A-17, Table 3). Water quality in the upper portions of Cedar Creek was therefore classified unpolluted. Characteristics for samples collected at Osc-1, on the other hand, fell within the moderately polluted range (Appendix Table A-17, Table 3). Communities at both sites consisted of a variety of taxa,

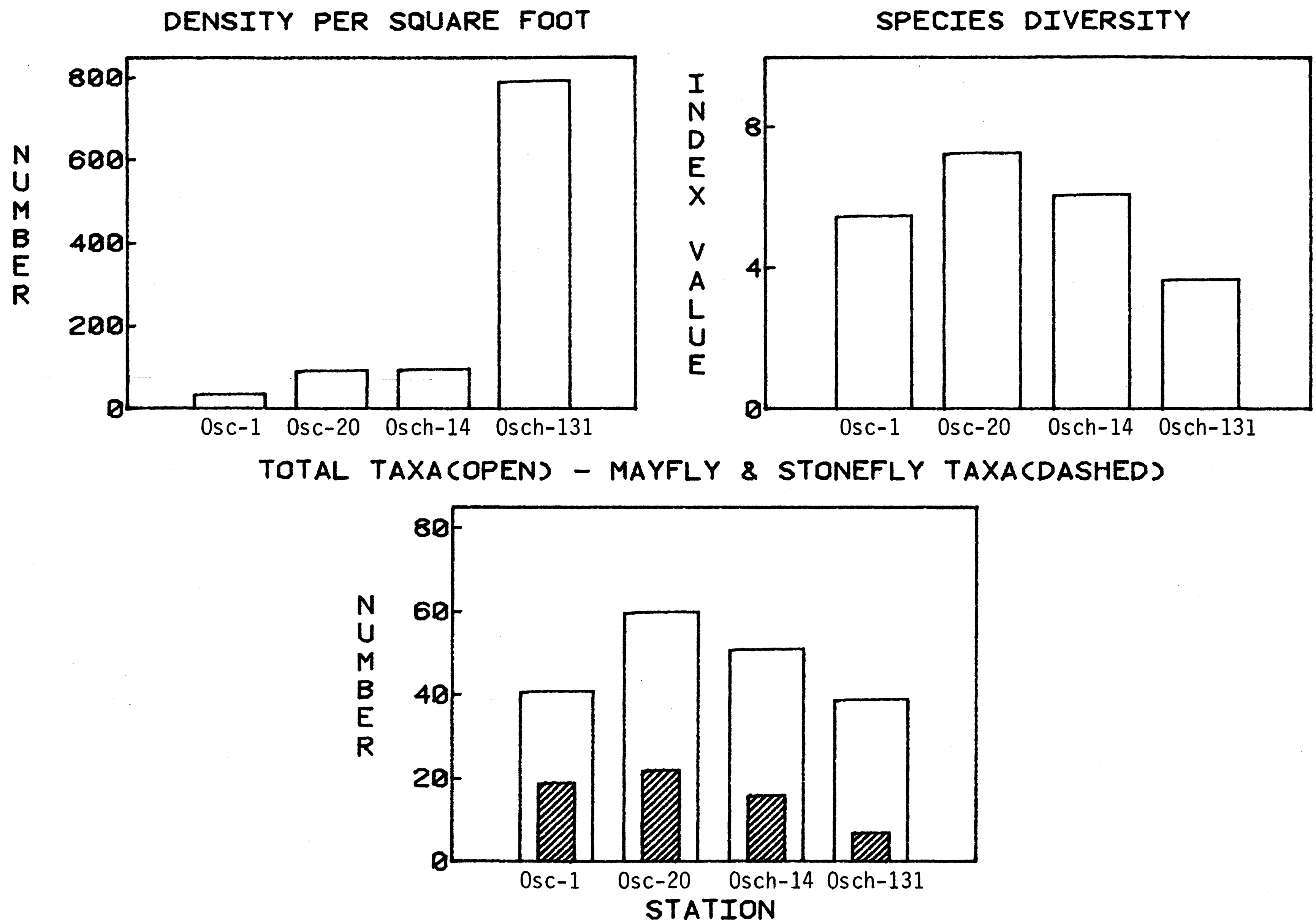


FIGURE 38. BENTHIC INVERTEBRATE COMMUNITY CHARACTERISTICS FOR SAMPLES FROM PRAIRIE TRIBUTARIES OF THE SAC RIVER- 1975-76.

many being sensitive or facultative toward pollution. Structure, however, of these communities was quite different (Fig. 39). The community of Osc-1 consisted primarily of Cheumatopsychid caddisflies, Stenelmid beetles, and flies. This community was similar to only four other sites in the Osage River Basin (Appendix Table A-23). This community clustered with two of the four sites (Appendix Table A-24). Three of the similar sites were located on prairie streams (Og-49, Olo-4, and Olo-5). The fourth site was at the mouth of the Pomme de Terre River (Op-13). Dominant taxa at Osc-1 included:

Caddisflies (30%)		Beetles (27%)		Flies (19%)	
Cheumatopsyche sp.	94%	*Stenelmis* sp.	100%	Chironomidae	49%
Rhyacophila sp.	3%			Simuliidae	32%
Hydropsyche cuanis	1%			*Eriocera* sp.	10%

Mayflies (12%)	
Ephoron sp.	37%
Stenonema pulchellum	21%
Heptagenia sp.	10%

The benthos community at Osc-20 was unique. Dominant taxa consisted of molluscs, mayflies and beetles. This community was not similar to any other community within the Osage River Basin nor did it cluster with any other site. Dominant invertebrates belonged to the following taxa:

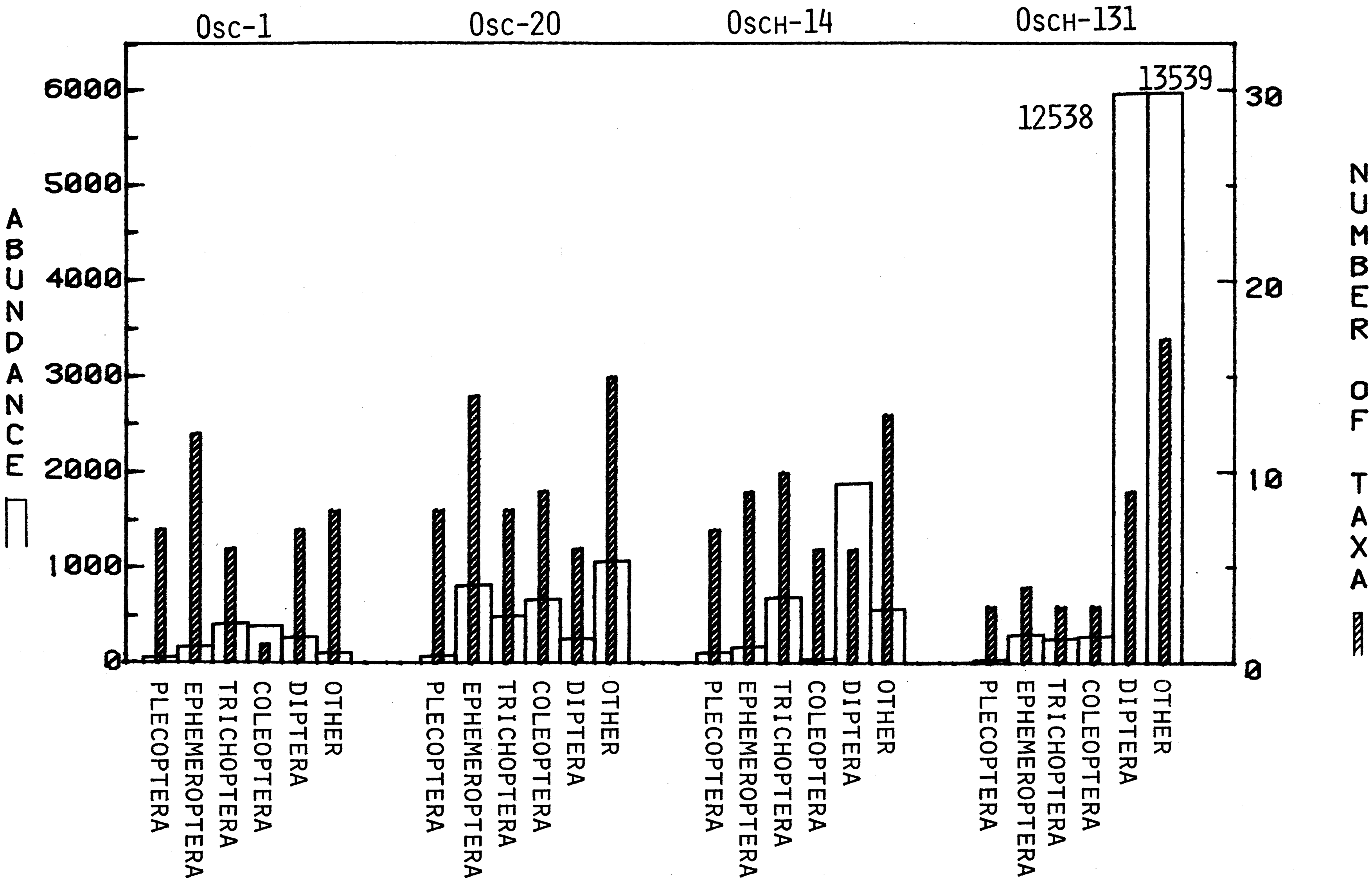


FIGURE 39. COMMUNITY STRUCTURE OF BENTHIC INVERTEBRATES BY ABUNDANCE AND TAXA FOR SAMPLES FROM PRAIRIE TRIBUTARIES OF THE SAC RIVER- 1975-76.

Other (31%)		Mayflies (24%)		Beetles (20%)	
Sphaeriidae	45%	Stenacron interpunctatum	50%	Stenelmis sp.	91%
Oligochaeta	35%	Pseudocloeon sp.	11%	Psephenus herricki	4%
Goniobasis sp.	10%	Stenonema femoratum	11%	Ectopria nervosa	3%

Caddisflies (15%)	
Agapetus sp.	68%
Cheumatopsyche sp.	26%
Rhyacophila sp.	4%

The reason for the limited benthos community in lower Cedar Creek is not known. Point source discharges were negligible. Cedar Creek did not appear enriched and non-point sources did not appear to overly affect this reach. Regardless of the cause, the periodic flooding this lower reach now receives will not help the situation.

Horse Creek

Horse Creek is a major tributary to Cedar Creek. Like Cedar Creek, Horse Creek originates in west-central Dade County, just south of Lockwood, Missouri. Throughout its course, Horse Creek forms the boundary between the Western Plains and the Ozark Highland provinces (Fig. 0). Of all the streams in the Sac River Basin, this stream is geographically and physically the closest to the prairie streams of the Western Plains Province. Horse Creek is approximately 71 miles long and joins Cedar Creek at river mile 16. Truman Reservoir does not include any of Horse Creek within its boundaries.

Two collection sites were established on Horse Creek. The upper site

(Osch-131) was located at a Dade County road crossing about 1 mile northwest of Lockwood, Missouri (Fig. 4, Table 2). Aquatic habitat at this site was degraded by poor farming practices, overgrazing by livestock, and point source pollution discharges in the watershed. These point discharges consisted of treated sewage effluent from several facilities serving Lockwood which enter Horse Creek upstream from this sample site (Table 1). The combination of these problems has degraded this portion of Horse Creek and rendered it incapable of supporting a diverse invertebrate community. Riffle substrate consisted largely of finer sand and gravel sized limestone fragments. Although this riffle was stable, it did not provide the varied habitat types similar to most other intergrade streams. Water clarity was mostly clear, temperatures moderate and periphyton growths excessive during fall and winter months.

Site Osch-14 was located on the lower reaches in Cedar County (Fig. 4, Table 2). Aquatic habitat in this portion had improved; however, portions of the watershed between these two sampling sites have been strip mined for coal, quarried for limestone and intensively farmed. Degradation was severe enough in Barton County to classify 15 miles of Horse Creek moderately polluted from non-point erosion and sedimentation (Missouri Department of Conservation 1978).

Substrate at Osch-14 had improved. Variable sized fragments of limestone comprised the riffle at this site. Included were areas of exposed bedrock. Water clarity during all collection dates was slightly to moderately turbid, suggesting the influence of non-point problems on this stream. Water temperatures were moderate and periphyton growth was not excessive. Invertebrate density in the lower portion of Horse Creek was light, averaging 95 organisms per square foot (Appendix Table A-17). Benthic invertebrate

community characteristics consistently approached but fell below minimum criteria for unpolluted Missouri streams (Fig. 38, Appendix Table A-17, Table 3). Water quality in lower Horse Creek was classified moderately polluted primarily because of non-point influences. Benthic invertebrate taxa collected at Osch-14 were evenly distributed among the major groups and consisted of pollution tolerant, facultative and sensitive forms (Fig. 39). This community was similar to 11 other communities within the Osage River Basin, two-thirds of them being on prairie streams (Appendix Table A-23). This community clustered with nine sites, eight of which were prairie stream sites (Appendix Table A-24). Specific taxa which were dominant at Osch-14 consisted of the following:

Flies (54%)		Caddisflies (20%)		Other (16%)	
Simuliidae	54%	*Cheumatopsyche* sp.	93%	Oligochaeta	49%
Chironomidae	38%	*Rhyacophila* sp.	3%	Sphaeriidae	33%
Bezzia/*Probezzia*, ...,	5%	*Ochrotrichia* sp.	2%	Planariidae	9%

Water quality in the headwaters of Horse Creek (Osch-131) was classified polluted. Benthic invertebrate density was the highest recorded in the Osage River Basin, averaging 793 organisms per square foot (Fig. 38, Appendix Table A-17). Benthic invertebrate community characteristics were lower than those at Osch-14 (Fig. 38). A majority of these characteristics fell in the polluted range (Appendix Table A-17, Table 3) and many of the organisms (84 percent) were from pollution tolerant taxa (Fig. 39). Dominant taxa collected at this site consisted of the following:

Other (50%)		Flies (46%)		Mayflies (1%)	
Oligochaeta	76%	Simuliidae	88%	*Caenis* sp.	64%
Lirceus sp.	20%	Chironomidae	11%	*Baetis* sp.	32%
Physa sp.	2%	*Culicoides* sp.	<1%	*Stenonema femoratum*	3%

The benthos community at Osch-131 was similar to those at only two other sites in the Osage River Basin: Spruce Creek in the South Grand drainage (Ogds-1) and Mulberry Creek in the Marais des Cygnes (Omdcml-1). This community did not cluster with any other site in the survey.

The degradation in upper Horse Creek can be stopped only if point source discharges and improper land use are improved. Continued pollution will not only cause present problems to worsen but also cause further degradation downstream. In fact, it's possible that the reduced benthos community in lower Cedar Creek could be related in part to the problems in upper Horse Creek.

In summary, water quality at the 20 sampling sites located on streams throughout the Sac River Basin were influenced by several different factors. The streams within this basin flow primarily across the Springfield Plain Region of the Ozark Highland Province. This region is transitional between the prairies of the Western Plains Province and the Missouri Ozarks of the Ozark Highland Province. Likewise, the streams draining these areas possessed an intergrade of physical and biological characteristics between the two provinces. The streams draining the western part of the Springfield Plain Region were more prairie-like and were influenced more by non-point pollution problems than the streams draining the eastern side. Problems found in the intergrade streams which resembled Ozark-type streams were caused primarily by point source pollutants, specifically poorly treated sewage effluent.

Problems in the Sac River Basin associated with channelization were virtually non-existent but were offset by the loss of habitat to reservoir construction. The completion of Stockton Reservoir prior to this survey (1969) and Harry S. Truman Reservoir (1978) have dramatically altered reaches within this basin. Improper operation of the hydroelectric facilities at Stockton Dam have degraded water quality in the Sac River below Stockton Reservoir. Encroachment by reservoir water from Truman Reservoir has threatened habitat essential for the Niangua darter, a threatened species, in Brush Creek (Osbh-3).

In all, point pollution, non-point pollution, and reservoir construction have temporarily or permanently altered 317 miles of the Sac River and its major and minor tributaries. This represents 17% of the original Sac River Basin. One quarter of this altered mileage represents degradation from point and non-point pollution. Reservoir construction makes up the remainder.

Water quality at a majority of the 20 sites sampled during 1975-76 was classified unpolluted (12). These sites were distributed throughout the basin. Five sites had moderately polluted water quality and in all cases degradation was caused by a combination of point or non-point problems. The three polluted sites (Os-49, Osls-103, and Osch-131) appeared to have serious water quality problems. Conditions will not improve at these sites unless improper landuse practices are changed, inadequate sewage treatment is substantially improved and the present operation of Stockton Dam for hydroelectricity is altered to protect the downstream habitat.

Biologically, the benthic invertebrate communities in the Sac River Basin were quite diverse and tended to be similar to communities at Ozark stream sites. This diversity of taxa in the Sac River Basin was exemplified by the variety of taxa collected in the basin. Among the eight subdivisions,

this number of taxa (172) was only equaled by the minor mainstem tributaries for the most taxa. Only the communities from intergrade streams draining the western edge of the Springfield Plain Region (Sons, Cedar and Horse creeks) more closely resembled prairie streams, both physically and biologically. In general, communities from these western intergrade streams were less diverse and half of them (Oss-18, Osc-20, and Osch-131) were not included in any cluster. Even though the characteristics of some streams within the Sac River Basin favored prairie streams and others favored Ozark streams, the intergrade nature of all 20 sites could be seen in several ways. The large number of taxa found in the Sac River Basin resulted from the variety of habitat types produced by the transition between the prairies and Ozarks. Sites from the Sac River Basin also appeared in 9 of the 13 clusters developed by statistically comparing the benthos communities at sites throughout the Osage River Basin. This variety of community types and structure further attest to the intergrade nature of the Sac River and its tributaries.

POMME DE TERRE RIVER

The Pomme de Terre River and its tributaries drain 615 square miles at Hermitage, Missouri (U.S. Geological Survey 1980). This drainage lies in the western portions of the Central Plateau and Osage-Gasconade Hills regions of the Ozark Highland Province (Fig. 0). The mainstem Pomme de Terre River flows north for 135 miles from its headwaters in west-central Webster County to its mouth located near Warsaw, Missouri (Benton County). Geographically, the upper 115 miles of the Pomme de Terre River form the western boundary of the Central Plateau Region. The remaining 20 miles flow through the Osage-Gasconade Hills Region. Much of the watershed is forested, interspersed with small, elevated plateaus. Its population,

although sparse, is supported mainly on small farms. Mineral deposits are virtually non-existent in the Central Plateau Region drained by the Pomme de Terre River. A few small deposits of lead and iron are found in the Osage-Gasconade Hills Region (Sauer 1920).

Physically, the Pomme de Terre River and its tributaries were typical Ozark streams. Water clarity was clear becoming turbid for brief periods following heavy runoff from rainfall. Normal water temperatures were moderate throughout its course and were not influenced by the seven small springs which were located within its watershed (Vineyard and Feder 1974). Substrate consisted of fragments of chert and limestone. The angular configuration and variability in size of this substrate provided large interstitial spaces and numerous microhabitats for diverse invertebrate production. This habitat type is typical of Missouri Ozark streams.

Average discharge in the unaltered Pomme de Terre River at Hermitage was 620 cubic feet per second over a 40 year period (U.S. Geological Survey 1961). Construction of Pomme de Terre Reservoir for flood control purposes in 1961 altered this flow regime. Since 1961, the average discharge at Hermitage has been 457 cubic feet per second (U.S. Geological Survey 1980). In addition, the completion of Truman Reservoir altered the lower 28 miles of river. All totaled, these two Corps of Engineers projects have altered 21% of the original mileage of streams in the Pomme de Terre River Basin.

Pollution in this basin was confined to point discharges of treated sewage effluent and low level discharges through Pomme de Terre Dam. These discharges have altered an additional 32 miles of stream within the basin. Although non-point pollution sources exist in this basin, their effects appeared minimal.

Biologically, the Pomme de Terre River and its tributaries support 78

species of fish comprising 16 families, including the proposed nationally threatened Niangua darter. It inhabits a 10 mile stretch in the headwaters of the mainstem Pomme de Terre River in Greene and Webster counties. Benthic invertebrate taxa totaled 114 at the six sample sites located on the mainstem (4) and Lindley Creek (2), a major tributary. In general, water quality in the basin was quite good. The presence of 30 taxa of sensitive mayfly and stonefly was evidence of its good condition.

Pomme de Terre River (Mainstem)

Water quality in the Pomme de Terre River was monitored at four sites located throughout its course. Two sites were established above Pomme de Terre Reservoir (Op-55 and Op-83) and two downstream from the dam (Op-27 and Op-13) (Fig. 4).

The uppermost site (Op-83) was located on an order 5 segment of the mainstem Pomme de Terre River in southeast Polk County (Fig. 4, Table 2). Habitat at this site and throughout the mainstem Pomme de Terre River was much like the streams draining the eastern portion of the Springfield Plain Region. It consisted of long pools interspersed with short, well defined, stable riffles. Vineyard and Feder (1974) list four small springs that discharge into the Pomme de Terre River, some distance upstream from Op-83. These springs discharged into tributaries located in Webster and Greene counties. Benthos samples were collected from a permanent, stable riffle consisting of chert and limestone fragments. These fragments varied greatly in size and shape. Water at Op-83 was consistently clear and temperatures were moderate. Periphyton growths on the riffle substrate were dense at times but were not considered excessive. The watershed as a whole was mostly forested and interspersed with pastureland.

There was no noticeable influence in this reach from non-point sources

of pollution. Point sources were limited to six small sewage treatment lagoons which discharged into tributaries that were dispersed throughout the watershed upstream from Op-83 (Table 1). Combined population equivalence of these six lagoons was 536.

No evidence of degradation from pollution was found in this reach of the Pomme de Terre River. Invertebrate density was light to moderate, averaging 137 organisms per square foot. Community characteristics were consistently high and exceeded minimum criteria for unpolluted Missouri streams (Fig. 40, Appendix Table A-19, Table 3). Likewise, the benthos community was quite diverse and consisted of pollution sensitive taxa (Fig. 41). These taxa included several species of naiades. Water quality was classified unpolluted at Op-83. This headwater community consisted of the following major taxa:

Flies (28%)		Mayflies (25%)		Beetles (16%)	
Chironomidae	84%	*Tricorythodes* sp.	36%	*Stenelmis* sp.	94%
Bezzia/*Probezzia*, ...,	8%	*Stenonema mediopunctatum*	25%	*Psephenus herricki*	4%
Simuliidae	5%	*S. pulchellum*	8%	*Ectopria nervosa*	1%

The community at Op-83 was similar to communities at 23 other sites in the Osage River Basin (Appendix Table A-23). The majority of these sites were on Ozark (56%) and intergrade (30%) streams. This community clustered with eight other Ozark and intergrade streams (Appendix Table A-24). These communities were characterized by mayfly-fly-beetle communities and all had very good water quality conditions. The community at Op-83 was closest aligned with the community immediately downstream at Op-55.

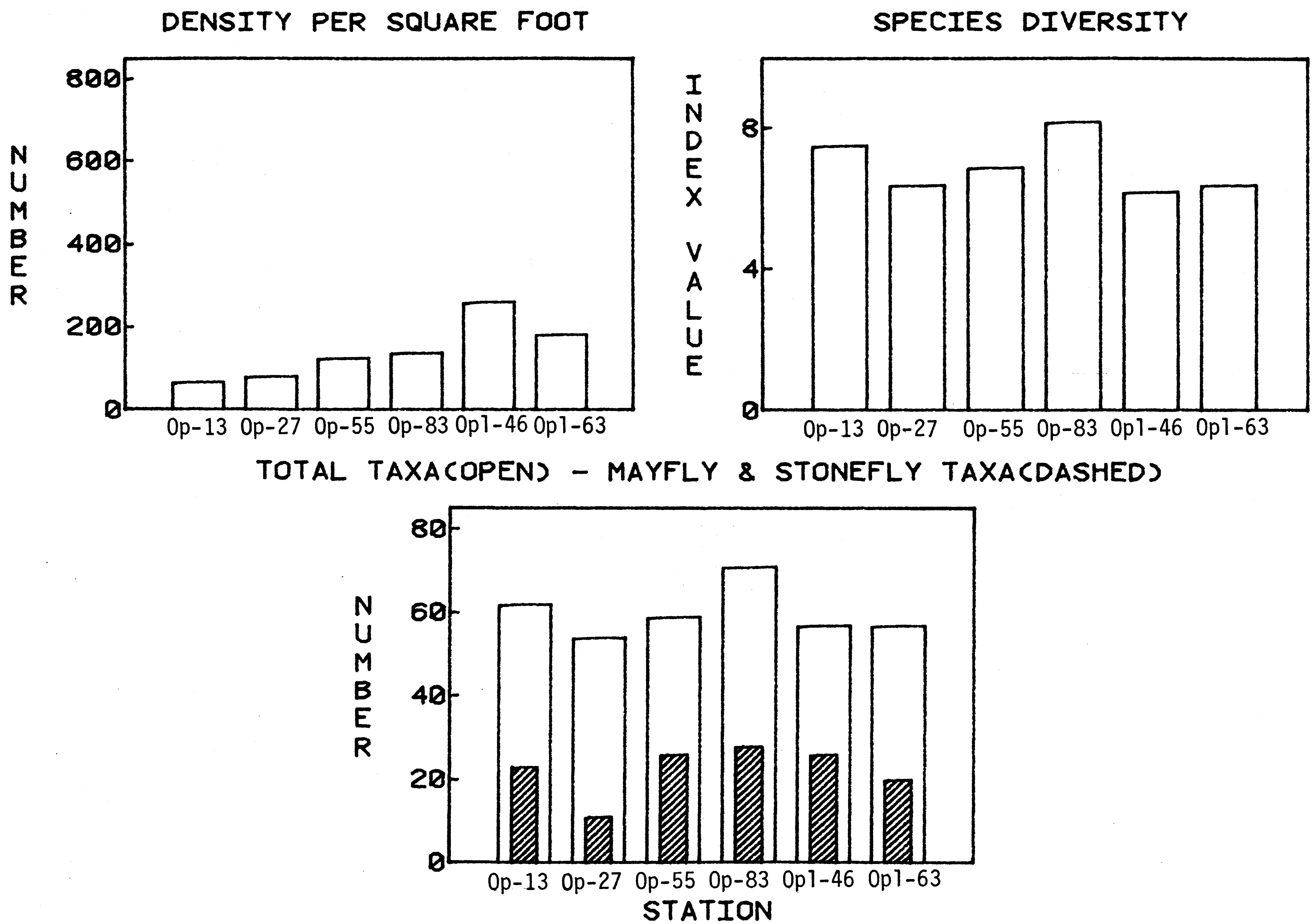


FIGURE 40. BENTHIC INVERTEBRATE COMMUNITY CHARACTERISTICS FOR SAMPLES FROM THE MAINSTEM POMME DE TERRE RIVER AND LINDLEY CREEK- 1975-76.

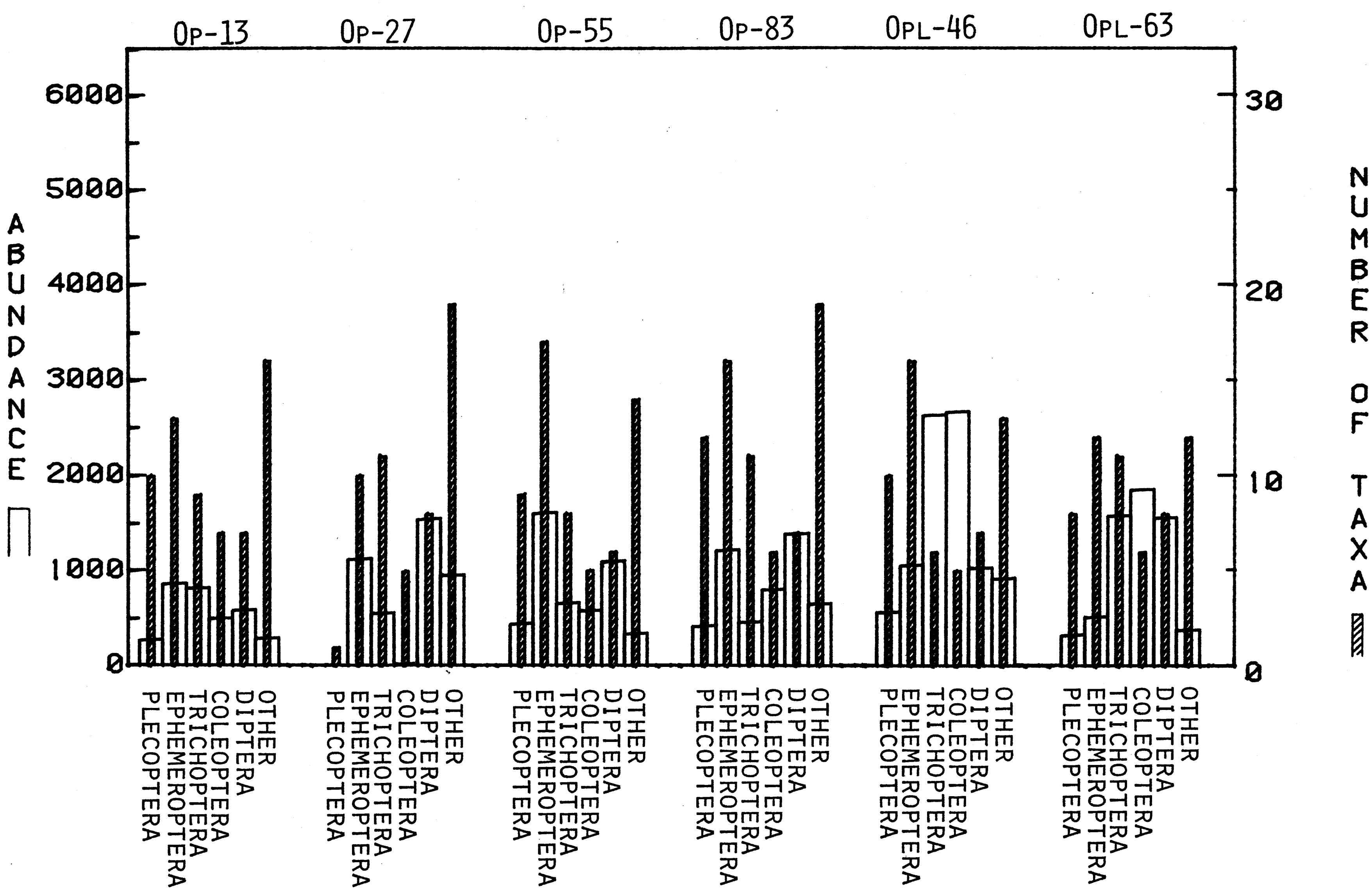


FIGURE 41. COMMUNITY STRUCTURE OF BENTHIC INVERTEBRATES BY ABUNDANCE AND TAXA FOR SAMPLES FROM THE MAINSTEM POMME DE TERRE RIVER AND LINDLEY CREEK- 1975-76.

The unpolluted conditions at Op-83 indicate that upstream conditions have not been seriously altered by human activities. This is important because a 10 mile reach of the extreme headwaters, beginning 11 miles upstream from Op-83, is inhabited by Niangua darters. Any degradation would destroy this population of rare darters (Pflieger 1978).

Stream habitat, physical features, and biological conditions in the mainstem Pomme de Terre River at Op-55 were much the same as those at Op-83. This site (Op-55) was located about 5 miles north of Bolivar, Missouri (Fig. 4, Table 2). This reach is within the upper 3 miles of the flood pool of Pomme de Terre Reservoir and susceptible to periodic flooding.

Pollution discharges were confined to point sources and consisted of discharges from seven smaller sewage treatment lagoons (total P.E.=1061) and the oxidation ditch serving Bolivar (P.E.=13,410) (Table 1). Most of these discharges entered the headwaters of Piper Creek, a tributary which drains the eastern portion of Bolivar. Piper Creek enters the Pomme de Terre River about 2 miles upstream from Op-55.

Two small springs enter tributaries of the Pomme de Terre River, upstream from Op-55, just east of Bolivar (Vineyard and Feder 1974). As at Op-83, they did not influence the habitat at Op-55. Similarily, no detectable degradation was found attributable to the point discharges or periodic flooding from Pomme de Terre Reservoir. Benthic invertebrate average densities and the number of sensitive mayfly and stonefly taxa at Op-55 were virtually identical to those at Op-83 (Fig. 40, Appendix Table A-19). Total taxa and annual diversity were slightly lower at Op-55. Regardless, all benthic invertebrate community characteristics met or exceeded minimum criteria for unpolluted Missouri streams. Water quality

at Op-55 was therefore classified unpolluted (Appendix Table A-19, Table 3). Community structure of the benthos community at Op-55 was quite similar to that at Op-83 (Fig. 41). Coefficients of similarity showed a close alignment (C=69). In addition to Op-83, the community at Op-55 was similar to 28 other communities at sites in the Osage River Basin (Appendix Table A-23). The proportion of these sites which were located on Ozark, intergrade and prairie streams was the same as at Op-83. Finally, the benthos community at Op-55 was in the same cluster with Op-83 which is further testimony of the homogeneity of the upper portion Pomme de Terre River. The benthic invertebrate community at Op-55 consisted of the following dominant taxa:

Mayflies (34%)		Flies (23%)		Caddisflies (14%)	
Tricorythodes sp.	25%	Chironomidae	76%	*Cheumatopsyche* sp.	84%
Stenonema pulchellum	21%	Simuliidae	21%	*Chimarra obscura*	10%
S. mediopunctatum	9%	*Bezzia/Probezzia*, ...,	2%	*Rhyacophila* sp.	2%
		Beetles (12%)			
		Stenelmis sp.	97%		
		Psephenus herricki	2%		
		Dubiraphia sp.	<1%		

Water quality, 2.5 miles downstream from Pomme de Terre Dam (Op-27), was quite different from the conditions which existed upstream from the reservoir (Fig. 4, Table 2). Low level discharges through the dam have caused this change. The purpose of these discharges was to adjust water levels in the reservoir for flood control purposes. After summer stratification, these discharges are deficient in oxygen and high in decomposition products. These

conditions have stressed the aquatic community downstream from the Pomme de Terre Reservoir, resulting in a decline in the fishery and benthos communities. The water discharged from the dam is also quite rich in nutrients and water temperatures are much lower than other reaches of the river. For example, temperatures during the summer sampling period at Op-55 and Op-83 were between 25-26 degrees centigrade. Water temperatures during the same period at Op-27 did not exceed 14 degrees. Periphyton and algae growths were also quite dense during most of the year at Op-27. These degraded conditions were the basis for classifying the first 8 miles of the Pomme de Terre River below the dam polluted and the next 24 miles moderately polluted (Missouri Department of Conservation 1978).

Biologically, this portion of the Pomme de Terre River was not as productive as the previous two sites. It also did not support a diverse assemblage of benthic invertebrates. Physically, the riffle at Op-27 was comparable to those sampled at Op-55 and Op-83. However, all categories of benthic invertebrate community characteristics were reduced when compared to the other sites in the Pomme de Terre River Basin (Fig. 40, Appendix Table A-19). They primarily fell in the moderately polluted range (Table 3). Average density was considered light (81 organisms per square foot). Although reduced in diversity and abundance, the structure of this community was comparable to the previous sites (Fig. 41) and consisted of a variety of pollution sensitive, facultative, and tolerant taxa.

The community at Op-27 was quite similar to the communities at the other mainstem Pomme de Terre River sampling sites (Appendix Table A-20. In addition, 17 other sites within the Osage River Basin had communities similar to that at Op-27 (Appendix Table A-23). Most of these 20 sites were on Ozark streams (65%). This community was included in the largest

cluster occupied by 17 other sites (Appendix Table A-24). Ozark stream sites dominated this cluster and the communities were composed primarily of midges, mayflies, and caddisflies. The following taxa typified the benthos community at Op-27:

Flies (37%)		Mayflies (27%)		Other (23%)	
Chironomidae	91%	*Tricorythodes* sp.	58%	*Goniobasis* sp.	52%
Simuliidae	7%	*Stenonema pulchellum*	29%	Oligochaeta	36%
Bezzia/Probezzia, ...,	1%	*Potamanthus* sp.	6%	*Ferrissia* sp.	4%

Caddisflies (13%)	
Cheumatopsyche sp.	71%
Agapetus sp.	15%
Chimarra obscura	5%

Although quite a few taxa were considered pollution sensitive or facultative at Op-27, habitat alterations caused by discharges from Pomme de Terre Dam have affected the benthic invertebrates in this reach. These problems have caused a substantial reduction in stonefilies (Fig. 41) and lowered benthic invertebrate community characteristics. Water quality in this reach (Op-27) was therefore classified moderately polluted. The similarity and clustering of this community with many other sites that had diverse communities and unaffected water quality suggests that the damaging discharges are periodic and abatement through wise planning could improve ιe conditions which exist.

The lower sampling site on the Pomme de Terre River (Op-13) was inundated by Truman Reservoir in 1978. The site was situated at a stable

gravel riffle, 13 miles above its confluence with the Osage River (Fig. 4, Table 2). Geographically, this reach of the Pomme de Terre River borders the Osage-Gasconade Hills and Springfield Plain regions. Physically, it was a typical Ozark stream. Substrate consisted of chert and limestone fragments, varying in size from fine sands to coarse rock and rubble. Unlike upstream sites, the substrate at Op-13 tended to consist of finer grades. Water clarity for the most part was clear and did not appear to be overly influenced by non-point pollution problems. Water temperatures had become more moderated from those below the dam at Op-27 and periphyton growths at times were heavy. Chemically, according to limited data, the Pomme de Terre River at Op-13 appeared similar to the Sac River at Os-4 (Appendix Table A-6).

Point source discharges of pollution identified during the survey were limited to the sewage treatment lagoon complex serving Hermitage, Missouri (P.E.=200) and two smaller lagoons (Table 1). No major non-point problems were identified. The major alteration in the vicinity of Op-13 was the permanent inundation of the lower 24 miles by Truman Reservoir. The lotic habitat present during 1975-76 no longer exist.

Water quality in this reach was classified unpolluted. All benthic invertebrate community characteristics were above minimum criteria for unpolluted Missouri streams (Fig. 40, Appendix Table A-19, Table 3). Invertebrate density was light, averaging 67 organisms per square foot. This density was the lowest recorded in the Pomme de Terre River Basin (Fig. 40). The community at this site was quite diverse and consisted of numerous pollution sensitive and facultative taxa (Fig. 41). Dominant groups consisted of caddisflies, mayflies, and flies. Although this community was made up of numerous sensitive forms, it was similar to only

eight other sites in the Osage River Basin (Appendix Table A-23). Many of these sites (50%) were on reaches of prairie streams which were not seriously degraded. The benthos community at Op-13 clustered with two other sites, Olo-4 on the Little Osage River and Osc-1 on Cedar Creek. All three sites had large concentrations of Cheumatopsychid caddisflies. Specific groups and taxa collected at Op-13 during 1975-76 consisted of the following:

Mayflies (26%)		Caddisflies (24%)		Flies (18%)	
Stenonema pulchellum	32%	*Cheumatopsyche* sp.	81%	Chironomidae	70%
Tricorythodes sp.	28%	*Agapetus* sp.	6%	Simuliidae	25%
Potamanthus sp.	20%	*Chimarra obscura*	5%	*Hexatoma* spp.	2%
Isonychia sp.	7%				

Beetles (15%)	
Stenelmis sp.	97%
Psephenus herricki	1%

Lindley Creek

Lindley Creek is a major tributary of the Pomme de Terre River, entering from the east. It originates near Buffalo, Missouri and flows northwest for 46 miles before joining the Pomme de Terre River. Throughout its course, Lindley Creek flows through the Central Plateau Region (Fig. 0) and physically represents a typical Ozark stream. At Polk, Missouri, near its mouth, Lindley Creek drains 112 square miles and has an average discharge of 87.4 cubic feet per second over 23 years (U.S. Geological Survey 1980).

The middle mainstem of the Pomme de Terre River and the lower 24 miles (52%) of Lindley Creek form the two arms of Pomme de Terre Reservoir.

Seventy-five percent of this mileage (18 miles) is permanently flooded by conservation pool and the remaining 8 miles are included within the flood pool. The only other alterations in the Lindley Creek Basin were in the extreme headwaters. According to the Missouri Department of Conservation (1978), treated sewage effluent from a severely overloaded facility serving Buffalo, Missouri (P.E.=1620) has seriously polluted 3.5 miles of a small tributary and affected the first mile of Lindley Creek below this tributary (Table 1).

Water quality in Lindley Creek during 1975-76 was monitored at two sites, Opl-46 and Opl-63 (Fig. 4, Table 2). In general, these sites were quite similar physically, chemically and biologically. About the only detectable differences were a slightly denser growth of periphyton at Opl-63 especially during the winter months and the closer proximity of this site to the headwater pollution problems. In fact, Opl-63 was the lower extent of the degradation noted in 1978. Benthic invertebrate density in Lindley Creek was considered moderate and was the highest recorded in the Pomme de Terre River Basin (Fig. 40, Appendix Table A-19). Community characteristics at both sites were quite similar to the characteristics at most other sites in the basin, however, in several instances these values only approached or equaled criteria for unpolluted Missouri streams (Appendix Table A-19, Table 3). This was especially apparent at the upper site (Opl-63) where the number of pollution sensitive mayfly and stonefly taxa were reduced and fell just below minimum criteria. This reduction suggests some influence from upstream pollution at this site.

Coefficients of similarity and cluster analyses showed that the two sites on Lindley Creek had similar communities based on their structure. Both communities were diverse consisting of numerous taxa which were

facultative or sensitive toward pollution (Fig. 41). Based on similarity coefficients, the benthos community at Opl-46 was similar to communities at seven other sites and the community at Opl-63 was like those at 13 (Appendix Table A-23). These communities in Lindley Creek were in the same cluster with one other site, Ow-11 on Weaubleau Creek. All three sites were dominated by beetles and caddisflies (Fig. 19 and 41). Unlike Weaubleau Creek, a number of prairie stream communities were similar to the two communities in Lindley Creek. Of the 7 and 13 similar communities to Opl-46 and Opl-63, 43% and 46% were from prairie streams in the Marmaton and South Grand river basins.

Based on the data collected from Lindley Creek during 1975 and 1976, water quality at Opl-46 was classified unpolluted. Water quality at the upper site (Opl-63) was considered to be moderately polluted based on the reduction of pollution sensitive taxa. Upgrading of the Buffalo facility would definitely improve the water quality at this site. Site Opl-63 appeared to be situated at the lower end of the zone of recovery to upstream pollution. Its similarity to Opl-46, as seen in the dominant taxa listed below, also demonstrates improved conditions at Opl-63 over what exists in the upstream tributary.

Opl-46

Beetles (30%)		Caddisflies (30%)		Mayflies (12%)	
Stenelmis sp.	98%	*Cheumatopsyche* sp.	83%	*Ephemerella dorothea/ excrusians*	37%
Ectopria nervosa	<1%	*Chimarra obscura*	11%	*Baetis* sp.	20%
Dubiraphia sp.	<1%	*Agapetus* sp.	4%	*Stenacron interpunctatum*	19%
				Heptagenia sp.	6%

Flies (12%)	
Chironomidae	52%
Simuliidae	40%
Bezzia/ Probezzia, ...,	6%

Opl-63

Beetles (30%)		Caddisflies (25%)		Flies (25%)	
Stenelmis sp.	97%	*Cheumatopsyche* sp.	67%	Chironomidae	55%
Psephenus herricki	2%	*Chimarra obscura*	19%	*Bezzia/ Probezzia*, ...,	25%
Dubiraphia sp.	<1%	*Hydroptila* sp.	8%	Simuliidae	15%

Mayflies (8%)	
Baetis sp.	41%
Pseudocloeon sp.	34%
Ephemerella dorothea/ excrucians	8%

In general, water quality throughout the Pomme de Terre River Basin was good and for the most part not greatly affected by human activities. Channelization was non-existent in the basin. Large non-point pollution problems were

not noted during the survey. Affected reaches in the basin were the result of poorly treated domestic sewage and low level discharges from Pomme de Terre Reservoir. Together, these adversely affected about 31 miles of flowing streams. The construction of Truman and Pomme de Terre reservoirs permanently flooded 67 miles of the mainstem Pomme de Terre River and Lindley Creek and another 32 miles of tributaries. An additional 51 miles of stream lie within their flood pools. A total of 150 miles (21%) are presently affected by these reservoirs. Pollution now affects only 2% of the basin since only 10 miles of the 31 have been flooded. Seventy-seven percent of the basin, including the mainstem and tributaries above Pomme de Terre Reservoir and the mid-reaches of Lindley Creek, are unpolluted productive Ozark streams. These support a diverse assemblage of aquatic fauna, including a sustaining population of Niangua darters in the headwaters of the Pomme de Terre River. It is extremely important that this 77% be afforded protection from any more degradation in the future.

NIANGUA RIVER

The Niangua River originates in north central Webster County near Marshfield, Missouri and flows north for 131 miles before joining the Osage River in central Camden County (Fig. 3). The upper reaches of the Niangua River and several tributaries support populations of Niangua darters. According to Pflieger (1978), these streams, which include the Little Niangua River, Greasy Creek, Starks Creek, Thomas Creek and Cahoochie Creek, contain 41% (52 miles) of the known remaining habitat of this species. Problems which would jeopardize these populations are few in this basin and must be guarded against in the future.

Aquatic habitat throughout the Niangua River Basin was typically Ozark.

Much of the 627 square miles drained by the Niangua River and its tributaries lay in the Central Plateau Region of the Ozark Highland Province. The lower reaches enter the Osage-Gasconade Hills Region (Fig. 0). The Niangua River is considered medium sized, having an average discharge of 627 cubic feet per second over a 40-year period of record (U.S. Geological Survey 1969). Thirteen springs discharge into the lower reaches of the river and its tributaries (Vineyard and Feder 1974). The largest spring entering the Niangua River is Bennett Spring, the fourth largest spring in Missouri. It enters the mainstem about midway down its course and has an average discharge of 100 million gallons per day. Another large spring, Hahatonka, discharges into the lower reach which is now impounded by Lake of the Ozarks. Hahatonka Spring has an average discharge of 48 million gallons per day and ranks twelfth in the state (Vineyard and Feder 1974). Many of the remaining springs discharge over a million gallons per day. Of the thirteen springs, nine enter the Niangua River and the remaining four enter the lower Little Niangua River.

Like the Pomme de Terre River Basin, non-point pollution sources were negligible in their effects on the streams in this basin. A potential threat, however, exists from five wood preserving plants distributed throughout Laclede and Dallas counties (Table 1). No evidence of degradation caused by these plants was detected during the survey. Most pollution entering the Niangua River and its tributaries was from small sewage treatment facilities. Those present were few, wide spread and caused only local degradation. The permanent flooding of 31 miles of the lower mainstem and Little Niangua River by Lake of the Ozarks was the only other effect noted during the survey.

Biologically, the Niangua River Basin supported the third most diverse assemblage of fish and benthic macroinvertebrates of the eight subdivisions

of the Osage River Basin. Eighty-five species of fish representing 17 families have been collected from this stream and its tributaries (Table 4). This included the Niangua darter (discussed previously) and the Bluestripe darter (Percina cymatotaenia), both of which are classified rare in Missouri (Nordstrom, Pflieger, Sadler and Lewis 1977) and are recommended for inclusion on the national list. The habitat of the Bluestripe darter includes 74 miles of the mainstem Niangua River from On-105 downstream beyond the entrance of Bennett Spring (Fig. 3). One hundred and twenty-five taxa of benthic invertebrates including 44 mayfly and stonefly taxa were collected from the six sites in the Niangua River Basin (Fig. 3, Table 5). A forested watershed and minimal influences from pollution and man caused alterations were responsible for the good water quality present in this basin.

Niangua River (Mainstem) and Bennett Spring

Water quality in the mainstem Niangua River was monitored at three sites. These sites were distributed in the headwater (On-105), middle (On-85), and lower reaches (On-33) of the river (Fig. 3, Table 2). The upper two sites were located above the nine springs which enter the mainstem. Benthos community structure in these reaches was not influenced by ground water. Site On-33, however, was downstream from Bennett Spring and four other springs, each discharging more than a million gallons per day. This may partially account for the unique benthic invertebrate community in this reach since it was similar to no other in the Osage River Basin. These springs, however, did not appear to influence the diversity of the benthos at this site to the extent of previous surveys (Duchrow 1977).

The upper site, On-105, was located at the Dallas County Route M crossing of the Niangua River (Fig. 3). This site and On-85 were within the 31-mile reach inhabited by the Niangua darter (Pflieger 1978). Aquatic habitat and

substrate at On-105 were typically Ozark. Water clarity was clear throughout the survey, even during periods of rainfall runoff. This consistent clarity demonstrates the lack of non-point problems in this watershed. Water temperature at On-105 were moderate and periphyton growths were generally not excessive. Riffle substrate was stable consisting of varying fragments of cherty dolomite.

The only pollution identified during the survey were discharges of treated sewage effluent from five facilities. Most discharges entered small tributary branches some distance upstream from On-105 (Table 1). A major discharge from an overloaded facility serving Marshfield, Missouri (P.E.=4108) entered the West Fork of the Niangua River about 14 miles upstream from On-105. This effluent degraded the first 7 miles of stream downstream from the plant (Missouri Department of Conservation 1978). The degradation was primarily in the form of lush periphyton and algal growths from excessive nutrients. The accumulative effects of these discharges were detected at On-105. Annual benthic invertebrate community characteristics bordered minimum criteria for unpolluted Missouri streams, whereas, seasonal characteristics generally exceeded these standards (Appendix Table A-21, Table 3). The benthos characteristics at this site were the most degraded within the Niangua River Basin (Fig. 42). This demonstrated some influence from these discharges on the aquatic community and water quality in this reach.

Invertebrate density at On-105 was moderately low, averaging 98 organisms per square foot. The structure of this commmunity was well distributed with pollution sensitive and facultative forms (Fig. 43). Structurally, this community appeared quite healthy. It was similar to four other sites in the Osage River Basin, all on unpolluted reaches of Ozark-type streams (Appendix Table A-23). Cluster analysis results were similar with five sites in the

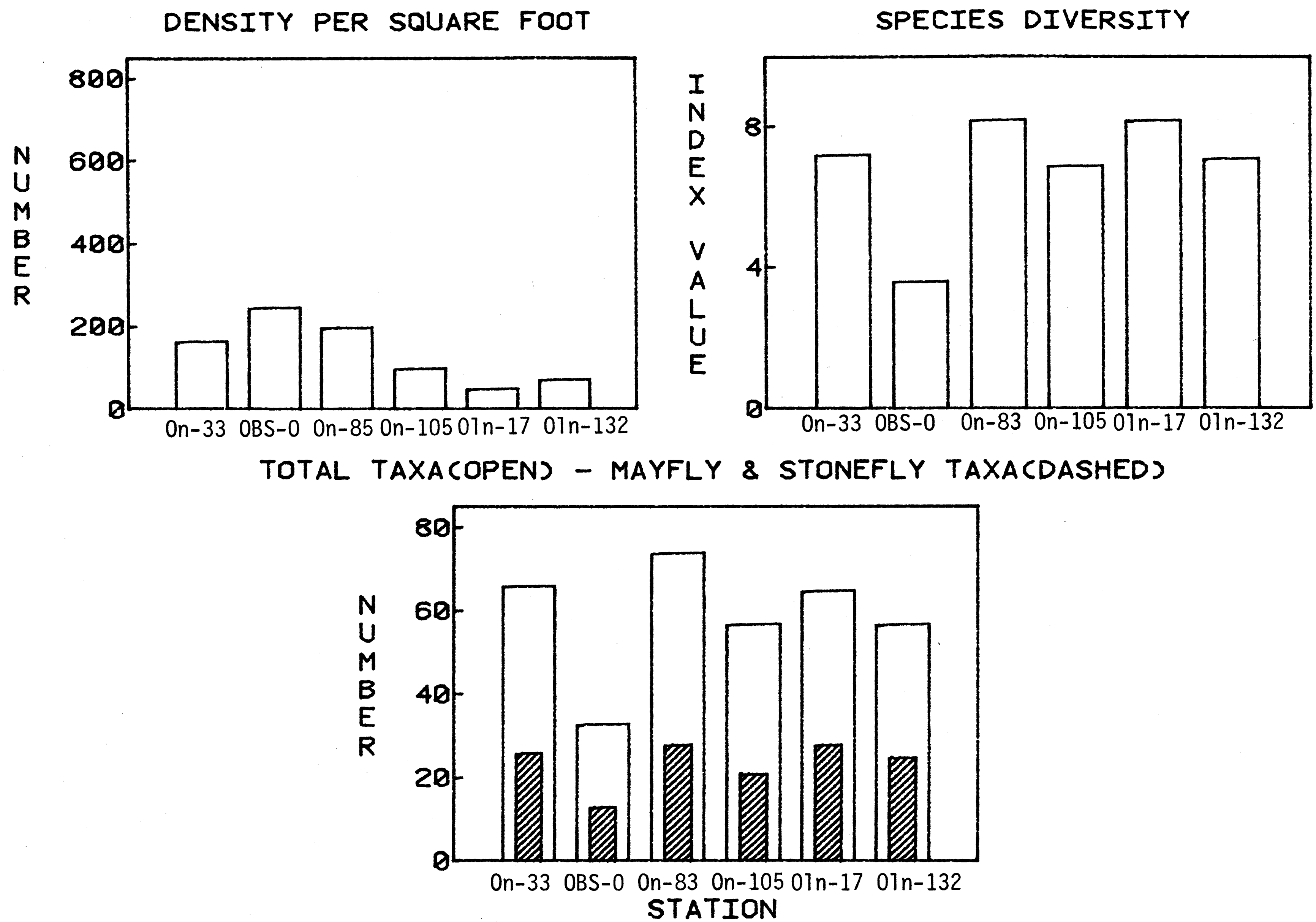


FIGURE 42. BENTHIC INVERTEBRATE COMMUNITY CHARACTERISTICS FOR SAMPLES FROM THE NIANGUA, BENNETT SPRING, AND LITTLE NIANGUA RIVERS- 1975-76.

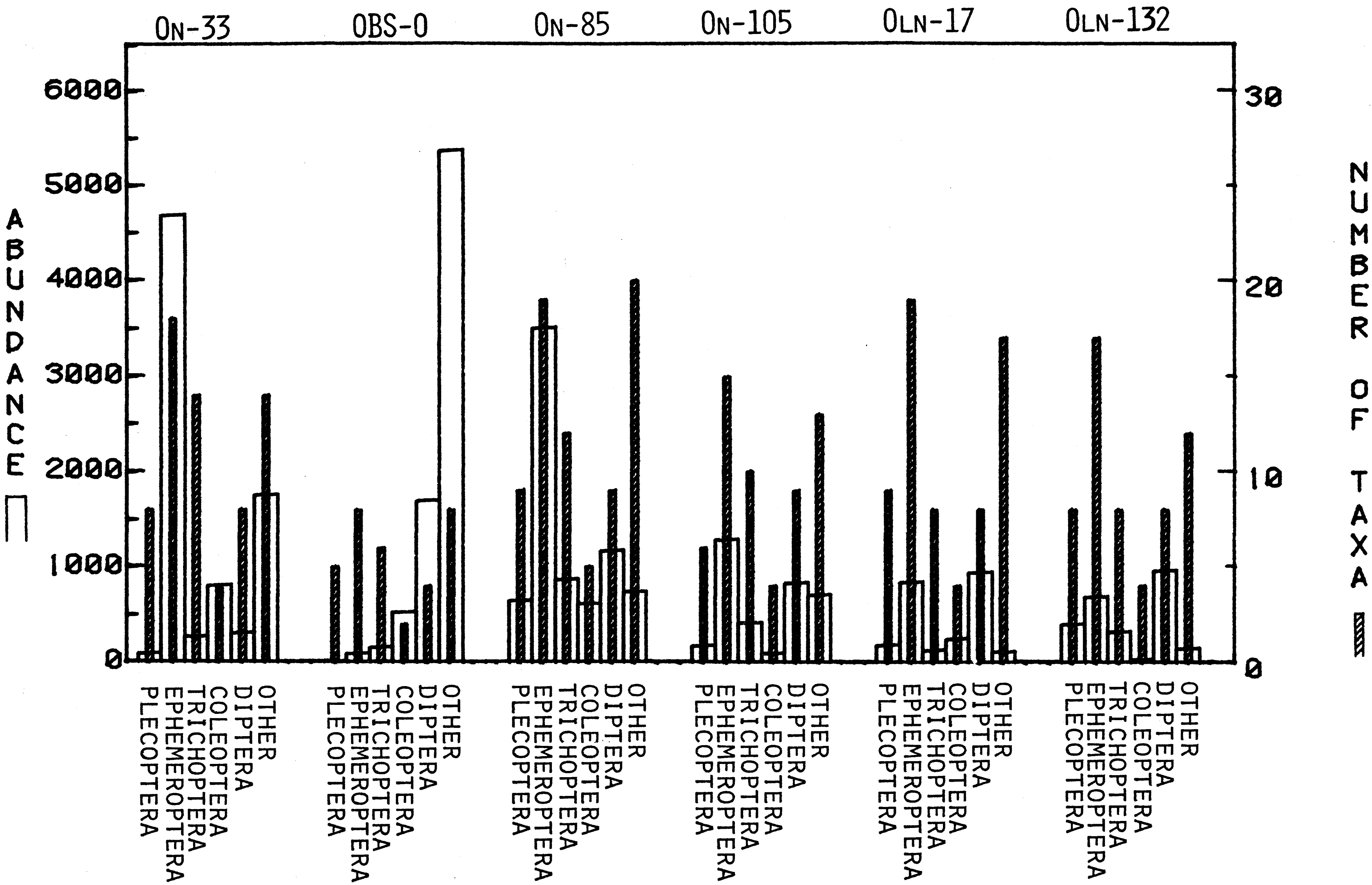


FIGURE 43. COMMUNITY STRUCTURE OF BENTHIC INVERTEBRATES BY ABUNDANCE AND TAXA FOR SAMPLES FROM THE NIANGUA, BENNETT SPRING, AND LITTLE NIANGUA RIVERS- 1975-76.

cluster, all on unpolluted reaches of Ozark Highland streams (Appendix Table A-24). Invertebrate taxa at this site and others in the cluster consisted of the following dominant groupings:

Mayflies (37%)		Flies (24%)		Other (20%)	
Ephemerella dorothea/ excrucians	32%	Chironomidae	80%	*Goniobasis* sp.	37%
Pseudocloeon sp.	23%	*Athetix lantha*	8%	*Gammarus* sp.	36%
Baetis sp.	11%	Simuliidae	6%	Oligochaeta	10%
Stenonema mediopunctatum	8%				

Caddisflies (12%)	
Cheumatopsyche sp.	37%
Agapetus sp.	89%
Symphitopsyche bifida	27%
Helicopsyche sp.	2%

Based on the data collected at On-105, water quality in this reach of the Niangua River was considered moderately polluted. The primary source of this degradation was poorly treated sewage effluent from the Marshfield facility. This pollution jeopardizes the future of the Niangua and Bluestripe darters in particular as well as the entire aquatic environment.

In 1978, a new activated sludge facility replaced the old lagoon system serving Marshfield. This new facility includes a storm water runoff catchment basin which reduces overloading during peak flows. These improvements have significantly reduced the threat to the downstream aquatic community and has improved the water quality at On-105.

The next site downstream, On-85, was located just northeast of Buffalo, Missouri (Fig. 3, Table 2). This site is within the range of the Bluestripe darter and near the lower extent of the Niangua darter's range (Pflieger 1978). Water quality at this site was quite good. Invertebrate density was considered moderate, averaging 198 organisms per square foot. This average was the highest density for the river sites in the basin (Fig. 42). Benthic invertebrate community characteristics were also the highest recorded at river sites within this basin. These characteristics consistently exceeded minimum criteria established for unpolluted Missouri streams on a seasonal and annual basis (Appendix Table A-21, Table 3).

Aquatic habitat at On-85 was excellent. The stable riffle at this site was similar to previous sites in the Central Plateau Region of the Ozark Highland Province. Limestone and chert fragments were quite varied in size and shape. Water clarity was always clear during sampling periods which encompassed varied discharge rates. Water temperatures were moderate and periphyton concentrations did not appear excessive. Pollution sources identified during the survey were few. Two small sewage treatment lagoons which discharged into small tributaries were the only point sources (Table 1). A wood treating operation identified in the watershed is a potential threat to the fauna in this reach but to date no problems with the operation have been found.

The diverse benthos community at On-85 was similar to those at thirteen other sites in the Osage River Basin (Appendix Table A-23). A majority of these sites were on Ozark (55%) and intergrade (30%) streams. This community was primarily represented by mayflies, flies, and caddisflies. It clustered with eight other sites, primarily located in the Pomme de Terre and Sac river basins. The community at On-85 consisted of the following dominant taxa:

Mayflies (46%)		Flies (15%)		Caddisflies (12%)	
Stenonema mediopunctatum	29%	Chironomidae	73%	Cheumatopsyche sp.	77%
Rhithrogena sp.	14%	Simuliidae	23%	Agapetus sp.	12%
Isonychia sp.	11%	Hexatoma spp.	3%	Neophylax sp.	3%
Tricorythodes sp.	11%				

The excellent water quality in this reach of the Niangua River is due to the recovery from enrichment problems upstream from On-105 and the absence of pollution entering in the vicinity of On-85. The conditions in this reach are favorable for the continuation of the populations of Niangua and Bluestripe darters which inhabit it.

Bennett Spring Branch enters the Niangua River about half way between On-85 and On-33 (Fig. 3). Bennett Spring is the fourth largest spring in Missouri, averaging 100 million gallons per day (Vineyard and Feder 1974). It is probably the best known and most highly developed spring in the state. The spring branch supports a popular trout fishery which is maintained by a Missouri Department of Conservation hatchery located nearby.

The spring branch was sampled at OBS-0 located at the first riffle downstream from the spring (Fig. 3, Table 2). The substrate at this site was firm, consisting of chert and limestone fragments of varying sizes. Water temperatures throughout the sampling year ranged between 12 and 16 degrees centigrade and clarity was always clear. Periphyton growths were not considered excessive. Fontinalis antipyretica, a water moss, was the dominant aquatic plant at the sampling site. In the past, there were concerns of excessive nutrients in the spring expressed by the Missouri and United States

Geological Surveys. Dye tracing studies showed that some surface drainage around Lebanon, Missouri was within the recharge basin of Bennett Spring (Dean, Williams, Lutzen, and Vineyard 1969). This included a portion of Goodwin Hollow Creek which received treated sewage effluent from Lebanon's west treatment plant and several small private lagoons (Table 1). Since this survey was conducted, the discharges into Goodwin Hollow have been transferred to a new facility which discharges into the Dry Auglaize Creek, east of Lebanon.

The benthic invertebrate community in Bennett Spring was much like those sampled in springs during previous surveys. Density from the samples collected at OBS-0 averaged 246 organisms per square foot (Fig. 42). Compared to other springs, this was considered moderate and compared favorably with other larger springs such as Big Spring (BS-0) and Round Spring (RS-0) in the Current River Basin (Duchrow 1977). Community characteristics for Bennett Springs were low in comparison to the values at other sites within the Niangua River Basin (Fig. 42, Appendix Table A-21). These characteristic values, however, were quite comparable to those at other springs for which data was available. Coefficients of similarity were used to compare the benthos community in Bennett Spring with communities in Montauk, Round, Big, Alley, and Greer springs located in the southeastern Ozarks. These coefficients showed that the communities at Big (C=72) and Round (C=58) springs in the Current River Basins were quite similar to those in Bennett Spring. The community at Greer Springs was the only community that was structurally very different from the others. No coefficient comparing the community in Greer Springs with the communities at the other five springs exceeded 15. The community in Bennett Spring neither clustered with nor was similar to any of the other communities sampled in the Osage River Basin.

The community in Bennett Spring Branch at OBS-0 was comprised of many pollution sensitive forms (Fig. 43), however, many of these forms were represented in quite low densities. Dominant taxa were as follows:

Other (68%)		Flies (22%)		Beetles (7%)	
Gammarus sp.	44%	Chironomidae	98%	_Optioservus sandersoni_	99%
Goniobasis sp.	41%	_Hexatoma_ spp.	1%	_Stenelmis_ sp.	1%
Planariidae	12%	Empididae	<1%		

According to these data, conditions in Bennett Spring did not appear appreciably different than those unpolluted springs in the southeastern Ozarks. Water quality in Bennett Spring was considered unpolluted based primarily on the presences of numerous pollution sensitive forms and its similarity to other unpolluted springs in the Ozark Highland Province. Since ground water influences have been shown to depress the criteria values shown in Table 3, these values were not used in this judgment. The abatement of pollution problems in the recharge basin of Bennett Spring will insure that high water quality in the spring continues.

The lower sampling site on the Niangua River was at On-33 (Fig. 3), Table 2). This locality was just upstream from the confluence of Mill Creek and the Niangua River. Four relatively large springs, including Bennett Spring, discharge into the Niangua River within 20 miles upstream from this sampling site. This inflow of ground water, however, does not appear to significantly influence this reach of river either physically or biologically. Physically, the aquatic habitat in the Niangua River at On-33 appeared much like that at the upper two sites. One difference though is that the Niangua

River is a larger river at On-33. Riffle substrate was quite stable, consisting of chert and limestone similar to other Central Plateau Region streams. Water clarity was always clear suggesting minimal non-point pollution problems in the basin. Water temperatures were moderate and were comparable to the upper sites. Periphyton growths were not excessive.

Point pollution sources within this reach were restricted to the discharge from Bennett Spring Trout Hatchery and the effluent from two small sewage treatment lagoons (total P.E.=560). The potential of pollution also existed from three wood treating plants located within the zone of influence of On-33 (Table 1).

Biologically, this reach of the Niangua River was outside the range of the Niangua darter and at the lower extent of the Bluestripe darter's range. The aquatic invertebrate community in this reach was represented by many pollution sensitive forms (Fig. 43). Benthic invertebrate community characteristics were high and consistently exceeded minimum criteria for unpolluted Missouri streams (Appendix Table A-21, Table 3). The structure of this community was diverse and consisted of many pollution sensitive taxa with a very large number being mayflies (63%). Invertebrate density at this site was considered moderate, averaging slightly less than that at On-85 (Fig. 42, Appendix Table A-21). Based on these data, the water quality in this reach of the Niangua River was very good and classified unpolluted. Since community characteristics were high, it indicated little if any influence of groundwater from upstream springs. The community samples at On-33, however, was quite unique. Dominant taxa at this site consisted of the following:

Mayflies (63%)		Other (22%)		Beetles (10%)	
Ephemerella dorothea/ excrucians	54%	Goniobasis sp.	87%	Optioservus sandersoni	81%
Rhithrogena sp.	16%	Oligochaeta	8%	Psephenus herricki	10%
Stenonema pulchellum	8%	Planariidae	2%	Ectopria nervosa	5%

This community clustered with no other community in the Osage River Basin nor was it similar to any other community. Several of the dominant taxa collected at On-33 are typically found in high concentrations in stream reaches highly influenced by springs. The large abundance of the snail, Goniobasis sp., is an example. The overall diversity of benthos, however, has not been reduced as normally happens in reaches which are influenced by ground water discharges. Of primary importance is that this reach showed no evidence of degradations from upstream pollution sources.

Downstream from this site, the only stream habitat alteration on the Niangua River has been from inundation by reservoir construction. Lake Niangua has flooded 2 miles, beginning 7 miles downstream from On-33. Lake of the Ozarks has covered the lower 19 miles from its confluence with the Osage River to within 17 miles of On-33. Collectively, these have permanently affected 21 miles (16%) of the mainstem.

Little Niangua River

This major tributary of the Niangua River enters from the west, about 6 miles upstream from the Osage River. The Little Niangua River starts north of Buffalo, Missouri (Dallas County) and flows for 63 miles before joining the Niangua River (Fig. 3). The upper half of its watershed is

within the Central Plateau Region and the lower half borders and enters the Osage-Gasconade Hills Region (Fig. 0). As in the mainstem Niangua River, the aquatic habitat in this tributary is typical of Ozark Highland streams.

Pflieger (1978) found the Niangua darter in a 13-mile reach of the upper Little Niangua River and three, 1-mile portions of lesser tributaries. This critical habitat accounts for 21% of the mainstem Little Niangua River. The Bluestripe darter has not been collected in this stream or its tributaries.

Four springs enter the lower portion of the Little Niangua River Basin from mainstem tributaries (Vineyard and Feder 1974). They are considered small springs and consequently their influence on the river is negligible. The largest of these four springs is Blue Spring, having a maximum recorded discharge of 3.2 million gallons per day (Vineyard and Feder 1974).

The Little Niangua River was sampled at two riffle sites located in the upper and lower portions of the basin. The upper site, designated Oln-132, was located within the habitat range of the Niangua darter whereas Oln-17 was below this range (Fig. 3). The physical habitat at these two sites seemed quite different. Riffle substrate at the upper site (Oln-132) was stable and consisted of a greater proportion of larger limestone and chert fragments. The riffle substrate at Oln-17 was not as stable as at the upper site. On the other hand, water temperatures and clarity at both sites were comparable and typically Ozarkian. Periphyton growths on the substrate appeared denser at the upper site (Oln-132), however, were not considered excessive at either.

In general, non-point pollution sources were virtually absent in the basin with the exception of a small gravel dredging operation which encompassed the upper sampling site. The 1978 pollution survey indicated possible effects

from this operation in a 1.5 mile reach. Point pollution sources upstream from Oln-17 were restricted to three small sewage lagoons which discharge into small tributaries (Table 1). One-half mile of Mack's Creek, a tributary, was considered moderately polluted from septic tank drainage (Missouri Department of Conservation 1978). Potential problems also existed from a wood treating plant located in the Thomas Creek Basin near Louisburg, Missouri (Table 1). Thomas Creek is one small tributary stream where Niangua darters have been collected (Pflieger 1978).

Benthic invertebrate density throughout much of the Little Niangua River was lower than in the mainstem Niangua River. In comparison to the Niangua River, average densities at Oln-17 and Oln-132 were considered low (Fig. 42), running 49 and 72 organisms per square foot, respectively (Appendix Table A-21). The low value at Oln-17 is in part a response to the less stable habitat. Community characteristics at these two sites were comparable to the data from the Niangua River. These characteristics exceeded minimum criteria established for unpolluted Missouri streams throughout most of the year (Appendix Table A-21, Table 3). The samples collected at Oln-17 and Oln-132 both consisted of numerous pollution sensitive taxa (Fig. 43), however, these communities were not similar to each other (C=24). Water quality at both sites was classified unpolluted. Apparently, the local gravel dredging at Oln-132 has not had a measurable impact on the benthos at this site. The dominant taxa collected at these two sites are listed below:

Oln-17

Flies (39%)		Mayflies (34%)		Beetles (10%)	
Chironomidae	47%	Stenonema pulchellum	20%	Stenelmis sp.	77%
Simuliidae	40%	S. mediopunctatum	20%	Optioservus sandersoni	11%
Atherix lantha	11%	Pseudocloeon sp.	18%	Psephenus herricki	6%
		Tricorythodes sp.	9%		

Oln-132

Flies (38%)		Mayflies (27%)		Stoneflies (16%)	
Chironomidae	92%	Isonychia sp.	23%	Allocapnia sp.	54%
Simuliidae	4%	Baetis sp.	13%	Isoperla spp.	23%
Hexatoma spp.	1%	Tricorythodes sp.	11%	Amphinemura delosa	17%
		Stenonema mediopunctatum	10%		
		S. pulchellum	9%		
		S. femoratum	9%		

Caddisflies (13%)	
Cheumatopsyche sp.	89%
Chimarra obscura	4%
Helicopsyche sp.	3%

Although the benthos communities in the Little Niangua River were a diverse assemblage of pollution sensitive forms, the two sites were not considered similar. The benthos community at Oln-132 was judged similar to 15 other sites in the Osage River Basin, primarily minor mainstem tributaries (Appendix Table A-23). The community at Oln-17, on the other hand, was similar only to the headwater site on Tavern Creek (Otv-30). The two Little

Niangua sites did, however, belong to the same cluster of five sites with midge-mayfly-stonefly dominant communities (Appendix Table A-24). The other three sites in this cluster consisted of On-105 on the mainstem Niangua River, Otv-30 on Tavern Creek, and Oma-23 on Maries River.

As discussed previously, water quality in the Little Niangua River was unpolluted. Pollutants did not have measurable effects on the biological community so the Niangua darter habitat in the headwaters does not seem in jeopardy. Gravel dredging in this area, however, must be discouraged. The only adverse affects to the river environment noted during this survey was the loss of 19% (12 miles) of the mainstem to Lake of the Ozarks.

In summary, water quality in the Niangua River Basin was very good. Evidence of degradation from non-point problems was non-existent. Effects from point source pollutants were restricted to 11.5 miles of stream within the basin. Seven of these miles were because of poorly treated sewage effluent from Marshfield, Missouri. This problem was abated in 1978. The only other effects identified in the basin were the permanent loss of 36 miles of stream to Lake of the Ozarks. In total, 5 percent of the streams in the basin have been adversely affected. This is the least degradation noted in any of the eight subdivisions which have been discussed.

Of great importance, is the large percentage of this basin which is critical habitat for two rare fish in Missouri. None of this habitat appears threatened at this time from point pollution sources, however, activities such as wood preservation and gravel dredging are present and must be closely monitored to insure the future survival of these species.

CONCLUSION

At its mouth, the Osage River drains 16,538 square miles of west central Missouri and eastern Kansas (Stout and Hoffman 1973). Within Missouri, this river basin originally included 9626 miles of flowing stream which were order 2 and larger. Data collected at 85 sampling sites indicated a minimum of 2044 miles (21%) of stream within the Osage River Basin, order 2 and larger, have been adversely affected by human activities. These activities included reservoir construction, point and non-point pollution problems, and channelization. Of these activities, the construction of four reservoirs, which presently impound 143,800 acres of water, have affected 1658 miles of river and stream habitat in the basin. This includes 903 miles of stream which are permanently flooded and 755 miles which lie within the flood pools of these reservoirs.

Point and non-point pollution problems affected a minimum of 293 miles of stream habitat in the basin. The source of these problems varied throughout the Osage River and its tributaries depending primarily on the geographical use of the watershed. Point source pollution problems, principally poorly treated domestic sewage, were responsible for most of the degradation in streams which drained the Central Plateau and Osage-Gasconade Hills regions of the Ozark Highland Province (Fig. 0). Degradation caused by non-point sources and channelization were almost non-existent in this province. The reverse was true in the prairie streams draining the Western Plains Province. Non-point problems have caused most of the degradation in these streams but much of their effects were masked by non-point problems. Erosion and sedimentation from agricultural lands and acid mine drainage have been responsible for most of the non-point problems in the Western Plains Province and the Osage River Basin as a whole. Most of the channelization

(93 miles) involved the Marais des Cygnes River and its tributaries.

The streams which drain the geographical region between the Ozarks and prairies possessed characteristics of both provinces. This intergrade region was known as the Springfield Plain Region and was drained by the Sac River and its tributaries. Even the pollution problems in the Sac River Basin were a combination of the point and non-point problems which affected the two main provinces.

Physical habitat in the streams of the Osage River Basin was also a function of the geographical area and the pollution problems which influences them. Prairie streams draining the Western Plains Province generally had low gradients, poorly developed riffles, substrates which consisted of fragmented shale, sand and/or silt, and moderately turbid waters. Ozark Highland Province streams, however, had higher gradients, well developed riffles and pools, a stable substrate composed of cherty limestone, and clear waters. Pollution problems in prairie streams generally increased both turbidity and the quantity of silt in the substrate, whereas, problems in the Ozark streams were generally expressed in excessive algal and periphyton growths and their damaging side effects.

Biologically, the Osage River Basin supported 113 species of fish representing 22 families. This included two species of darters, the Bluestripe and Niangua, which are considered rare in Missouri. The latter has also been recommended for inclusion on the national list of threatened species. In the basin, the Bluestripe darter inhabited specific reaches of the Sac and Niangua rivers. The Niangua darter also inhabited selected reaches of these rivers in addition to the headwaters of Pomme de Terre River, Tavern Creek, and lower reaches of Maries River. Benthic invertebrates were represented by 254 different taxa. Included in this were 60 taxa of mayfly and

and stonefly. These two insect orders are generally the first to be affected by pollution and are therefore considered quite sensitive. Their presences was considered indicative of good water quality.

In general, water quality in the basin was good with the eight subdivisions averaging about 25 percent of each being adversely affected by human activities. These effects ranged from a high of 76% of the area affected in the mainstem Osage River to a minimum of 5% in the Niangua River Basin. The remaining six subdivisions fell between these extremes: Pomme de Terre River Basin - 23%; Minor mainstem tributaries - 19%; Marais des Cygnes River Basin - 19%; Sac River Basin - 17%; South Grand River Basin - 16%; and the Marmaton-Little Osage River Basin - 10%. Many of these affects in these basins are irreversible consisting primarily of reservoir construction and channelization. Effects attributed to pollution, however, are reversible through wise land use and abatement of point source problems. These actions would improve the overall water quality in the basin. Of equal importance will be to guard against future degradation of the 75% of the Osage River Basin which is still in good habitat quality.

LITERATURE CITED

Anderson, R. O. 1959. A modified flotation technique for sorting bottom fauna samples. Limnology and Oceanography. 4(2):223-225.

Anonymous. 1883. History of Cass and Bates counties, Missouri. St. Joseph Steam Printing Company, St. Joseph, Missouri. 1,414 pp.

Anonymous. 1889. History of Laclede, Camden, Dallas, Webster, Wright, Texas, Pulaski, Phelps, and Dent counties. Goodspeed Publishing Company, Chicago, Illinois. 1,219 pp.

Atkenson, W. O. 1918. History of Bates County. Historical Publishing Company, Topeka, Kansas. 983 pp.

Austin, M. E. 1972. Land resource regions and major land resource areas of the United States (exclusive of Alaska and Hawaii). Agriculture Handbook 296. U. S. Department of Agriculture, Soil Conservation Service, Washington, D. C. 82 pp.

Beck, W. M., Jr. 1976. Biology of the larval chironomids. State of Florida, Department of Environmental Regulation, Technical Series 2(1):1-58.

Borror, D. J. and D. M. Delong. 1971. An introduction to the study of insects, Third Edition. Holt, Rinehart and Winston, Incorporated, New York, New York. 812 pp.

Bray, J. R. and J. T. Curtis. 1957. An ordination of the upland forest communities of southern Wisconsin. Ecological Monographs. 27:325-349.

Burks, B. D. 1953. The mayflies, or Ephemeroptera of Illinois. Illinois Natural History Survey Bulletin. 26(1):1-316.

Burlington, R. F. 1962. Quantitative biological assessment of pollution. Journal of the Water Pollution Control Federation. 34(2):179-183.

Chandler, J. R. 1970. A biological approach to water quality management. Journal of the Water Pollution Control Federation. 42(3):415-423.

Clifford, H. F. 1966. Some limnological characteristics of six Ozark streams. Missouri Department of Conservation D-J Series Number 4. 55 pp.

Clifford, H. T. and W. Stephenson. 1975. An introduction to numerical classification. Academic Press, New York, San Francisco, and London. 229 pp.

Collier, J. E. 1959. Geographical areas of Missouri. Missouri Council for Social Studies, Missouri Information Pamphlet, Park College, Parkville, Missouri. C(1):1-28.

Curry, L. L. 1958. A key for the larval forms of aquatic midges (Tendipedidae - Diptera) found in Michigan. Central Michigan College, Mount Pleasant, Michigan. Presented at the Sixth Annual Meeting of the Midwest Benthological Society, April 17-18, 1959. 22 pp.

Czarnezki, J. M. 1978. Missouri fish kill investigations, 1977. Missouri Department of Conservation D-J Project F-19-R-4, Study W-3, Job No. 2. Progress Report. 11 pp.

Czarnezki, J. M. 1981. Missouri fish kill investigation, 1980. Missouri Department of Conservation Project S-1-R-29, Study W-9. Performance Report. 26 pp.

Dean, T., J. H. Williams, E.E. Lutzen and J. D. Vineyard. 1969. Geologic report on the Bennett Spring project, Laclede and Dallas counties. Engineering Geology Section, Missouri Geological Survey, Rolla. 12 pp.

de la Torre-Bueno, Jr. 1937. A glossary of Entomology. Science Press Company, Lancaster, Pennsylvania. 330 pp.

Dieffenbach, W. H. and F. M. Ryck, Jr. 1976. Water quality of the Elk, James, and Spring river basins, 1964-1965. Missouri Department of Conservation Aquatic Series 15. 25 pp.

Duchrow, R. M. 1974. Water quality of the North, Salt, and Cuivre river basins. Missouri Department of Conservation Project F-1-R-22, Study W-1, Job No. 3. Final Report. 33 pp.

Duchrow, R. M. 1976a. Water quality of Prairie, Cowskin, and Beaver creeks, Douglas County, Missouri. Missouri Department of Conservation D-J Project F-19-R-2, Study W-3, Job No. 3. Progress Report. 21 pp.

Duchrow, R. M. 1976b. Water quality of Bryant and Hunter creeks. Missouri Department of Conservation D-J Project F-19-R-2, Study W-3, Job No. 3. Progress Report. 10 pp.

Duchrow, R. M. 1977. Water quality of the Current, Jack's Fork, Eleven Point, Little Black, and Warm Fork of the Spring rivers, 1974. Missouri Department of Conservation D-J Project F-19-R-2, Study W-1, Job No. 1. Final Report. 80 pp.

Duchrow, R. M. 1978. The effects of a barite tailings pond dam failure upon the water quality of Mill Creek and Big River, Washington County, Missouri. Presented at the 26th Annual Meeting of the North American Benthological Society, May 10-12, 1978, Winnipeg, Manitoba, Canada. 48 pp.

Duchrow, R. M. and L. Trial. 1980. The effects of lead mine tailings on the water quality of Saline Creek and the Little St. Francis River, Madison County, Missouri. Missouri Department of Conservation Project S-1-R-28, Study W-11. Final Report. 21 pp.

Duchrow, R. M., E. F. Robinson-Wilson, and L. Trial. 1980. The effects of lead mine tailings on the water quality of Logan Creek, Reynolds

County, Missouri. Missouri Department of Conservation Project S-1-R-28, Study W-12. Final Report. 29 pp.

Everitt, B. S. 1974. Cluster analysis. Halsted Press, New York, New York. 122 pp.

Fajen, O. F. 1959. Movement and growth of smallmouth bass on small Ozark streams. Masters of Arts Degree, University of Missouri, Columbia, Missouri. 96 pp.

Fajen, O. F. 1973a. The fish population as affected by stream improvements. Missouri Department of Conservation D-J Project F-1-R-22, Study S-13, Job No. 2. Progress Report. 10 pp.

Fajen, O. F. 1973b. Stabilization and improvement at Big Buffalo Creek. Missouri Department of Conservation D-J Project F-1-R-22, Study S-13, Job No. 1. Progress Report. 8 pp.

Frison, T. H. 1935. The stoneflies, or Plecoptera of Illinois. Illinois Natural History Survey Bulletin. 10(4):381-471.

Frison, T. H. 1942. Studies of North American Plecoptera. Illinois Natural History Survey Bulletin. 22(2):197-208.

Gaufin, A. R. 1958. The effects of pollution on a mid-western stream. Ohio Journal of Science. 58(4):197-208.

Grabau, M. C. 1955. A taxonomic study of naiades of Missouri dragonflies (Odonata-Anisoptera). Master of Science Thesis, Department of Entomology, University of Missouri, Columbia, Missouri. 120 pp.

Hester, F. E. and J. S. Dendy. 1962. A multiple-plate sampler for aquatic macroinvertebrates. Transactions of the American Fisheries Society. 91(4):420-421.

Hilsenhoff, W. L. 1970. Key to genera of Wisconsin Plecoptera (stonefly)

nymphs, Ephemeroptera (mayfly) nymphs, and Trichoptera (caddisfly) nymphs. Wisconsin Department of Natural Resources, Madison, Wisconsin. Research Report 67. 68 pp.

Hilsenhoff, W. L. 1975. Aquatic insects of Wisconsin. Wisconsin Department of Natural Resources, Madison, Wisconsin. Resources Technical Bulletin 89. 52 pp.

Johannsen, O. A. 1934. Aquatic Diptera. Part I. Nemocera, exclusive of Chironomidae and Ceratopogonidae. Cornell University Agricultural Experiment Station Memoir 164. 71 pp.

Kersh, G. M., Jr. 1977. Preimpoundment water quality of Harry S. Truman Reservoir. U. S. Army Corps of Engineers, Kansas City District, Water Control Section, 700 Federal Building, Kansas City, Missouri. 46 pp.

Kuester, D. R. 1964. Part V. The benthos of the streams in the Meramec River basin as related to water quality. pp. 234-240. In Water quality in the Big, Bourbeuse, and Meramec river basins. The Department of Public Health and Welfare in Missouri, Missouri Water Pollution Board, Jefferson City, Missouri.

Lewis, P. A. 1974. Taxonomy and ecology of Stenonema mayflies (Heptageniidae:Ephemeroptera). U. S. Environmental Protection Agency, Cincinnati, Ohio. Environmental Monitoring Series, EPA 570/4-74-006 (December). 80 pp.

Margalef, R. 1957. La teoria de la informacions en ecologia. Mem. Real. Acad. Ciencias y Artas de Barcelona. 32:373-449.

McBride, T. 1977. A landform map for Missouri. Master of Science Thesis. University of Missouri, Columbia, Missouri. 36 pp.

Merritt, R. W. and K. W. Cummins. 1978. An introduction to the aquatic insects of North America. Kendall/Hunt Publishing Company, Dubuque, Iowa. 441 pp.

Missouri Department of Conservation. 1978. An inventory of point and non-point water pollution sources in Missouri with notes regarding their impact upon fish and other aquatic life. Missouri Department of Conservation, Fish and Wildlife Research Center, 1110 College Avenue, Columbia, Missouri. 160 pp.

Missouri Department of Conservation. 1979. Unpublished stream resource data on file. Missouri Department of Conservation, Fish and Wildlife Research Center, 1110 College Avenue, Columbia, Missouri.

Missouri Department of Natural Resources. 1976. Water quality management basin plan for Osage-Gasconade river basin in accordance with section 303(E) of P.L. 92-500. Missouri Department of Natural Resources, Division of Environmental Quality, Water Quality Program, 2010 Missouri Boulevard, Jefferson City, Missouri. 339 pp.

Nordstrom, G. R., W. L. Pflieger, K. C. Sadler and W. H. Lewis. 1977. Rare and endangered species of Missouri. Missouri Department of Conservation, Jefferson City, Missouri and U. S. Department of Agriculture, Soil Conservation Service, Columbia, Missouri. 129 pp.

Peterson, A. 1960. Larvae of insects. Part II. Coleoptera, Diptera, Neuroptera, Siphonaptera, Mecoptera, Trichoptera. Edwards Brothers, Incorporated, Ann Arbor, Michigan. 416 pp.

Peterson, A. 1962. Larvae of insects. Part I. Lepidoptera and Hymenoptera. Edwards Brothers, Incorporated, Ann Arbor, Michigan. 315 pp.

Pflieger, W. L. 1971. A distributional study of Missouri fishes. University of Kansas Publications, Museum of Natural History. The University of Kansas Printing Service, Lawrence, Kansas. 20(3):225-570.

Pflieger, W. L. 1975. The fishes of Missouri. Missouri Department of Conservation, 2901 North Ten Mile Drive, Jefferson City, Missouri. 343 pp.

Pflieger, W. L. 1978. Distribution, status, and life history of the Niangua darter, Etheostoma nianguae. Missouri Department of Conservation Aquatic Series 16. 24 pp.

Robinson-Wilson, E. F. 1977. Missouri fish kill investigations, 1976. Missouri Department of Conservation D-J Project F-19-R-2, Study W-3, Job No. 2. Progress Report. 5 pp.

Ross, H. H. 1944. The caddisflies, or Trichoptera of Illinois. Illinois Natural History Survey Bulletin. 23(1):1-316.

Ross, H. H. and W. R. Horsfall. 1965. A synopsis of the mosquitoes of Illinois (Diptera, Culicidae). Illinois Natural History Survey Bulletin, Note Number 52. 50 pp.

Russell, T. R., L. K. Graham, D. M. Carlson, and E. J. Hamilton. 1980. Maintenance of the Osage River-Lake of the Ozarks paddlefish fishery. Missouri Department of Conservation, Fish and Wildlife Research Center, Fisheries Research Section, 1110 College Avenue, Columbia, Missouri. 33 pp.

Ryck, F. M., Jr. 1973a. Fish kill investigations, 1969. Missouri Department of Conservation Project S-1-R-19, Study W-3, Job No. 2. Progess Report. 6 pp.

Ryck, F. M., Jr. 1973b. Fish kill investigations, 1972. Missouri

Department of Conservation Project S-1-R-22, Study W-3, Job No. 2. Progress Report. 11 pp.

Ryck, F. M., Jr. 1973c. Fish kill investigations, 1970. Missouri Department of Conservation Project S-1-R-20, Study W-3, Job No. 2. Progress Report. 7 pp.

Ryck, F. M., Jr. 1974. Water quality survey of the southeast Ozark mining area, 1965-1971. Missouri Department of Conservation Aquatic Series 10. 22 pp.

Ryck, F. M., Jr. 1975a. The effects of scouring floods on the benthos of Big Buffalo Creek, Missouri. Proceedings of the 29th Annual Conference of the Southeastern Association of Game and Fish Commissioners, October 12-15, 1975, St. Louis, Missouri. 29:36-45.

Ryck F. M., Jr. 1975b. Missouri fish kill investigations, 1974. Missouri Department of Conservation D-J Project F-19-R-1, Study W-3, Job No. 2. Progress Report. 8 pp.

Ryck, F. M., Jr. 1976a. Water quality of the Big Piney River. Missouri Department of Conservation D-J Project F-19-R-2, Study W-4, Job No. 1. Final Report. 36 pp.

Ryck, F. M., Jr. 1976b. Missouri fish kill investigations, 1975. Missouri Department of Conservation D-J Project F-19-R-2, Study W-3, Job No. 2. Progress Report. 8 pp.

Sauer, C. O. 1920. The geography of the Ozark Highland of Missouri. University of Chicago Press, Chicago, Illinois. 245 pp.

Stout, L. N., and D. Hoffmann. 1973. An introduction to Missouri's geographical environment. Education Series Number 3. Missouri Geological Survey and Water Resources, Rolla, Missouri. 44 pp.

U. S. Army Corps of Engineers. 1979a. Water resources development by the U. S. Army Corps of Engineers in Kansas. U. S. Army Corps of Engineers, Southwestern Division, Main Tower Building 1200, Main Street, Dallas, Texas. 83 pp.

U. S. Army Corps of Engineers. 1979b. Unpublished hydrological data for the Osage River. Kansas City District, 700 Federal Building, Kansas City, Missouri.

U. S. Department of Agriculture, Soil Conservation Service. 1978. Missouri resource appraisal, 1978. 555 Vandiver Drive, Columbia, Missouri. 202 pp.

U. S. Environmental Protection Agency. 1972. Biota of freshwater ecosystems identification manuals. United States Government Printing Office, Washington, D. C. Volumns I-XI.

U. S. Environmental Protection Agency. 1973. Biological field and laboratory methods of measuring the quality of surface water effluents. Environmental Monitoring Series EPA-670/4-73-001, July 1973. 1,976 pp.

U. S. Geological Survey. 1961. Surface water records of Missouri. U. S. Department of the Interior, Geological Survey, 1400 Independence Road, Mail Stop 200, Rolla, Missouri. 163 pp.

U. S. Geological Survey. 1969. Water resources data for Missouri. Part I. Surface water records; Part II. Water quality records. U. S. Department of the Interior, Geological Survey, 1400 Independence Road, Mail Stop 200, Rolla, Missouri. 318 pp.

U. S. Geological Survey. 1970. Water resources data for Missouri. Part I. Surface water records; Part II. Water quality records. U. S. Department of the Interior, Geological Survey, 1400 Independence Road, Mail Stop

200, Rolla, Missouri. 482 pp.

U. S. Geological Survey. 1971. Water resources data for Missouri. Part I. Surface water records; Part II. Water quality records. U. S. Department of the Interior, Geological Survey, 1400 Independence Road, Mail Stop 200, Rolla, Missouri. 376 pp.

U. S. Geological Survey. 1974. Water resources data for Missouri. Part I. Surface water records; Part II. Water quality records. U. S. Department of the Interior, Geological Survey, 1400 Independence Road, Mail Stop 200, Rolla, Missouri. 372 pp.

U. S. Geological Survey. 1975. Water resources data for Missouri, Water Year 1975. U. S. Department of the Interior, Geological Survey, 1400 Independence Road, Mail Stop 200, Rolla, Missouri. 362 pp.

U. S. Geological Survey. 1976. Water resources data for Missouri. Water Year 1976. U. S. Department of the Interior, Geological Survey, 1400 Independence Road, Mail Stop 200, Rolla, Missouri. 300 pp.

U. S. Geological Survey. 1977. Water resources data for Missouri, Water Year 1977. U. S. Department of the Interior, Geological Survey, 1400 Independence Road, Mail Stop 200, Rolla, Missouri. 277 pp.

U. S. Geological Survey. 1978. Water resources data for Kansas. U. S. Geological Survey Water-Data Report KS-78-1, Water Year 1978. U. S. Department of the Interior, Geological Survey, 1950 Avenue 'A' - Campus West, University of Kansas, Lawrence, Kansas. 656 pp.

U. S. Geological Survey. 1980. Water resources data for Missouri. U. S. Geological Survey Water-Data Report MO-80-1, Water Year 1980. U. S. Department of the Interior, Geological Survey, 1400 Independence Road, Mail Stop 200, Rolla, Missouri. 343 pp.

Usinger, R. L. (ed.). 1963. Aquatic insects of California with keys to North American genera and California species. University of California Press, Berkeley and Los Angeles, California. 508 pp.

Vandenberg, R., and R. Patten. 1976. An assessment of benthos in the Sac River downstream from Stockton Dam. U. S. Army Corps of Engineers, Kansas City District, Water Control Section, 700 Federal Building, Kansas City, Missouri. 11 pp.

Vineyard, J. D. and G. L. Feder. 1974. Springs of Missouri. Missouri Geological Survey and Water Resources, Box 250, Rolla, Missouri. 267 pp.

Ward, H. B. and G. C. Whipple. 1959. Freshwater biology (Second edition), E. T. Edmondson, (ed.). John Wiley and Sons, New York, New York. 1,243 pp.

Wiggins, G. B. 1977. Larvae of the North American caddisfly genera (Trichoptera). University of Toronto Press, Toronto, Ontario, Canada and Buffalo, New York. 401 pp.

Wilhm, J. L. 1967. Comparison of some diversity indices applied to populations of benthic macroinvertebrates in a stream receiving organic wastes. Journal of the Water Pollution Control Federation. 39(10):1,673-1,683.

Williams, A. B. 1954. Speciation and distribution of crayfish of the Ozark Plateau and Ouachita Provinces. University of Kansas Scientific Bulletin. 34(12):803-918.

TABLES

Table 1. Discharges and potential pollution sources entering the Osage River system, 1975-1976.[1]

Facility					
Name	Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
1. BATES COUNTY					
Adrian, Mo.	T41N R31W S. 3 NW¼	lagoon	1,100	Big Deer Creek	Og-80
Butler, Mo.	T40N R31W S. 26 NW¼	lagoon	7,600	Mound Branch	Omdcm-4
Motts Food Lockers	T38N R29W S. 11 SE¼	lagoon	335	Panther Creek	O-238
Pine Tree Nursing Home	T40N R31W S. 16 NE¼	lagoon	107	Miami Creek	Omdcm-4
Miami R-1 School	T41N R33W S. 26 SE¼	lagoon	145	Miami Creek	Omdcm-12
Hooterville Trailer Park	T40N R31W S. 27 SE¼	lagoon	44	Mound Branch	Omdcm-4
Shermans Custom Slaughtering	T40N R31W S. 14 SW¼	lagoon	200	Mound Branch	Omdcm-4
Rich Hill Livestock Pavillion	T38N R31W S. 8 SE¼	lagoon	36	Muddy Creek	Og-80
Bates County Rock, Inc.	T40N R31W S. 30	mining	---	Miami Creek	Omdcm-4

Table 1. (continued)

Facility						
Name	Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
Pittsburg & Midway Coal Mining Co.	T40N R33W S. 2-11, 14-23 T41N R33W S. 26-35	mining	---	Hog Branch	Omdcml-1
Adrian Water Plant	T41N R31W S. 3 NW¼	backwash	---	Big Deer Creek	Og-80
Butler Water Plant	T40N R32W S. 24 NE¼	backwash	---	Miami Creek	Omdcm-4
Amoret Water Plant	T40N R33W S. 33 NE¼	backwash	---	Marais des Cygnes	Omdc-24
Rockville Water Plant	T38N R29W S. 14 SE¼	backwash	---	Panther Creek	O-238
Bates Co. PWSD #2	T41N R33W S. 10 SW¼	backwash	---	Miami Creek	Omdcm-12
Motts Food Lockers	T38N R29W S. 11 SE¼	lagoon	335	Panther Creek	O-238
Steel & King Cattle	T40N R32W S. 24 SW¼	no treatment	---	Miami Creek	Omdcm-4
2. BARTON COUNTY					
Liberal, Mo.	T33N R33W S. 35 SW¼	lagoon	1,650	Dry Wood Creek	Omw-6
Old Strip Mine Area with Acid Runoff	T32, 33N R33W	---	---	Dry Wood Creek and tributaries	Omw-6
3. BENTON COUNTY					
Warsaw, Mo.	T40N R22W S. 16 NE¼	lagoon (3 cell)	2,000	Lake of the Ozarks	---

Table 1. (continued)

Facility						
Name	Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
Cole Camp, MO.	T43N R21W S. 27, 26, 25, 36, 35, 34	Imhoff tank & trickling filter	1,100	Cole Camp Creek	Occ-11
Lincoln, Mo.	T42N R22W S. 26 NW¼	lagoon (2 single cells)	870 840	Cole Camp Creek Tributary to Little Tebo Creek	Occ-11
Ted Carlton Warsaw, Mo.	T40N R22W S. 26 N½	laundry	50	Tributary to Lake of the Ozarks	---
H & H Subdivision, Cole Camp, Mo.	T45N R21W S. 25 SW¼	lagoon	15	Williams Creek	Occ-11
Lake Hills Motel & Restaurant, Warsaw	T40N R22W S. 22 NW¼	lagoon	---	Lake of the Ozarks	---
H.W. Ramthun, Warsaw, Mo.	T40N R22W S. 22 NW¼	lagoon	36	Lake of the Ozarks	---
Oral Owens, R #2 Edwards, Mo.	T39N R20W S. 9 SE¼	lagoon	15	Deer Creek	Od-6
Woodrow Ferguson Warsaw Mo.	T40N R22W S. 16 SE¼	lagoon	10	Lake of the Ozarks	---
Westview Cafe, Warsaw, Mo.	T40N R22W S. 21 S½	lagoon	12	Lake of the Ozarks	---
Raymond Van Sooy, Greenwood, Mo.	T40N R23W S. 23, 24	lagoon	88	Tributary to Osage River	---

Table 1. (continued)

Facility: Name	Facility: Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
Chaplin Mobile Home Sales, Warsaw, Mo.	T39N R22W S. 3 NW¼	lagoon	32	Tributary to Osage River	---
Ralph Heaton, 205 W. 90th St., Kansas City, Mo.	T42N R22W S. 26, 35	lagoon	133	Tributary to Little Tebo Creek	---
Gravel Operation	T40N R21W S. 28 NW¼	---	---	Big Turkey Creek	Ot-5
Gravel Operation	T41N R21W S. 3 NW¼	---	---	Cole Camp Creek	Occ-11
H.W. Arnett, Warsaw, Mo.	T40N R22W S. 9 NW¼	livestock holding area (no treatment)	---	Grandview Beach Lake of the Ozarks	---
4. CAMDEN COUNTY					
Camdenton, Mo.	T38N R17W S. 25	lagoon	742	Tributary to Lake of the Ozarks	---
Camdenton, Mo.	T38N R17W S. 35	lagoon (2 cell)	1,765	Tributary to Lake of the Ozarks	---
Camdenton, Mo.	T38N R17W S. 24	lagoon	265	Tributary to Lake of the Ozarks	---
Camdenton, Mo.	T38N R17W. S. 24	lagoon (2 cell)	716	Tributary to Lake of the Ozarks	---

Table 1. (continued)

Facility: Name	Facility: Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
Camdenton, Mo.	T38N R16W S. 19	lagoon	850	Tributary to Lake of the Ozarks	---
Linn Creek, Mo.	T38N R16W S. 8 SW¼	lagoon	---	Tributary to Lake of the Ozarks	---
Gold Nugget Jct., P.O. Box 70, Camdenton	T39N R16W S. 28 NE¼	lagoon	11	Tributary to Lake of the Ozarks	---
Clarence Slenker, R#2, Box 70, Camdenton	T38N R16W S. 11 NW¼	lagoon	11	Ditch to the Lake of the Ozarks	---
Charles Burns, Burns Oil Co., Sunrise Beach	T39N R17W S. 35	lagoon	3	Ditch to the Lake of the Ozarks	---
Frank Gerbs, Gerbs Supermarket, Tipton	T38N R16W S. 19	lagoon	30	Lake of the Ozarks	---
Leslie Blair, Ozark Maid Candies, Osage Beach	T40N R16W S. 25 NE¼	lagoon	8	Lake of the Ozarks	---
Suburban Water & Sewer, Mariners Cove	T39N R16W S. 11 SW¼	Can-Tex Model 450	450	Lake of the Ozarks	---
Camdenton Medical Ctr., Hwy. 5, North of Camdenton	T35N R17W S. 14 SW¼	lagoon	73	Tributary to Lake of the Ozarks	---
Lewis & Mary Rowland, Bend Resort, Lake Ozark	T40N R17W S. 25 SE¼	septic tank/ sand filter	32	Lake of the Ozarks	---

Table 1. (continued)

Facility					
Name	Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
Deer Run Motel, Rt. 1, Box 23, Osage Beach	T39N R16W S. 16 SW¼	lagoon	14	Lake of the Ozarks	---
Ronald Sears, Rt. 1, Box 23, Osage Beach	T49N R15W S. 16	lagoon	43	Lake of the Ozarks	---
Chase Resorts, Lodge of 4 Seasons, Lake Ozark	T40N R16W S. 27 SE¼	extended aeration plant	1,000	Lake of the Ozarks	---
Mai Tai Corp., 9715 Groves, Afften	T39N R16W S. 12 NW¼	Walkers process Sparjair	200	Lake of the Ozarks	---
Clifton Chalk, Box 187, Linn Creek	T38N R16W S. 5 SE¼	lagoon	37	Lake of the Ozarks	---
Ozark Village Resort State Road HH, Lake Ozark	T40N R16W S. 26	septic tank & lagoon	3.1	Lake of the Ozarks	---
Gilmer Krantz, Lake Rd. 54-37, Osage Beach	T39N R16W S. 11 NE¼	4 septic tanks 2 sand filters	5.7	Lake of the Ozarks	---
H.C. Atkinson, Box 1 Tuscumbia	T39N R15W S. 6	lagoon	11	Lake of the Ozarks	---
Tan-Tar-A, Osage Beach	T39N R16W S. 17 NW¼	contact aeration extended aeration plant	300 200	Lake of the Ozarks	---

Table 1. (continued).

Facility					
Name	Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
Temple Hamna, Osage Beach, Mo.	T39N R16W S. 14 NW¼	lagoon	54	Lake of the Ozarks	---
Three Seasons Resort Lake Rd. 22A, Osage Beach	T39N R16W. S. 10 NE¼	2 1000 gal. septic tanks, and filters	---	Lake of the Ozarks	---
New Tribes Institute Box 459, Camdenton	T38N R17W S. 29 NW¼	lagoon	98	Lake of the Ozarks	---
Windemere Baptist Assembly Ranch	T38N R17W S. 31 SW¼	2 1-cell lagoons	---	Lake of the Ozarks	---
E.W. Dixon, Foxes IV Steak House, Sunrise Beach	T39N R17W S. 9 SE¼	lagoon	2.7	Lake of the Ozarks	---
Carl Williams, 54-42 Bar-B-Q, Osage Beach	T39N R15W S. 6 NE¼	lagoon	12	Lake of the Ozarks	---
Claud Skinner, Green-view Restaurant, Jct. Hwy. 5&7, Camdenton	T39N R17W S. 29 NW¼	lagoon	10	Lake of the Ozarks	---
A.B. Shoemate, Rt. 1 Camdenton	T38N R17W S. 24 SW¼	lagoon	22	Lake of the Ozarks	---
Frank Knauf & Robert Dame, Rt. 1, Box 101, Osage Beach	T39N R16W S. 11	lagoon	59	Lake of the Ozarks	---

Table 1. (continued)

Facility					
Name	Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
John & Jacob Drake Star Rt. 1, Box 288 Sunrise Beach	T40N R16W S. 33 SW¼	extended aeration plant	86	Lake of the Ozarks	---
Mary Kaminski, Star Rt. C, Box 101-A Camdenton	T39N R17W S. 33 NW¼	septic tank & closed sand filter	9	Lake of the Ozarks	---
Mrs. Leda Lash Osage Beach	T39N R16W S. 12 NW¼	lagoon	22	Lake of the Ozarks	---
School District RIII Osage Beach	T38N R16W S. 30 NW¼	sand filter	27	Lake of the Ozarks	---
Missouri State Park Board, Box 176, Jefferson Building Jefferson City	T39N R15W S. 33 SE¼	septic tank/ lagoon	300	Lake of the Ozarks	---
Missouri State Park Board	T39N R16W S. 24 NE¼	lagoon	120	Lake of the Ozarks	---
Missouri State Park Board	T39N R15W S. 17	lagoon	104	Lake of the Ozarks	---
Missouri State Park Board	T39N R15W S. 33 SE¼	lagoon	680	Lake of the Ozarks	---
Missouri State Park Board	T39N R15W S. 17 NE¼	lagoon	55	Lake of the Ozarks	---
Missouri State Park Board	T39N R15W S. 17 NE¼	lagoon	55	Lake of the Ozarks	---

Table 1. (continued)

Facility					
Name	Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
Model Homes, Camdenton	Unknown at this time	lagoon	18	Lake of the Ozarks	---
Ozark Fisheries, Inc.	T37N R14, 15W	Commercial fish hatchery	--- ---	Mill Creek Wet Auglaize Creek	Oawm-1 Oaw-5
5. CASS COUNTY					
Municipal Water Plant Archie, Mo.	T43N R31W S. 33 NE¼	backwash	---	South Grand River	Og-80
Garden City Water Plant	T44N R29W S. 30 SE¼	backwash	---	Panther Creek	Ogb-5
Harrisonville Water Plant	T44N R31W S. 4 NW¼	backwash	---	Town Creek	Og-80
Freeman Water Plant	T44N R32W S. 18 SE¼	backwash	---	Poney Creek	Og-80
Cleveland Water Plant	T45N R33W S. 32 NE¼	backwash	---	Massey Creek	Og-80
Peculiar Water Plant	T45N R33W S. 22 NE¼	backwash	---	East Branch of South Grand River	Oge-7
Pleasant Hill Water Plant	T46N R30W S. 19 NW¼	backwash	---	Big Creek	Ogb-5
Raymore Water Plant	T46N R32W S. 16 SW¼	backwash	---	East Creek	Og-100
Cantrell Sale Barn	T43N R31W S. 35 NE¼	lagoon	12	Eight Mile Creek	Og-80
Creighton School	T43N R29W S. 23 NE¼	lagoon	175	Knob Creek	Ogd-7

Table 1. (continued)

Facility					
Name	Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
Construction Industry Laborer's Training	T45N R32W S. 6 SW¼	extended aeration lagoon	40	East Creek	Og-100
Reorganized School District #2	T46N R32W S. 16 SE¼	lagoon	250	East Creek	Og-100
Lakeside Gardens	T46N R33W S. 25 NE¼	lagoon	210	East Creek	Og-100
Freeman School	T44N R32W S. 7 SW¼	lagoon	---	South Grand River	Og-100
Nickerson Farms	T44N R31W S. 16 NW¼	lagoon	---	East Branch	Og-80
Cass Recreation Park	Unknown at this time	lagoon	121		
Silver Lake Sewer Corp.	T46N R32W S. 16 SW¼	lagoon	562	Boggs Hollow	Og-100
Spencer's Addition	North of Peculiar, East of U.S. Hwy. 71	lagoon	140	Tributary to East Branch	Oge-7
Belton, Mo.	T46N R33W S. 23 NW¼	activated sludge	5,700	East Creek	Og-100
Raymore (Keenland), Mo.	T46N R32W S. 9 S½	tight line	120	Alexander Creek	Og-100
Raymore (Maplewood), Mo.	T46N R32W S. 15 NW¼	tight line	---	Grand Creek	Ogb-5
Lake Winnebago, Mo.	T46N R31W S. 9 SE¼	lagoon	900	Middle Big Creek	Ogb-5
Pleasant Hill, Mo.	T46N R30W S. 9 NW¼	lagoon	165	Duncan Branch-Big Creek	Ogb-5
Pleasant Hill, Mo.	T45N R30W S. 29 NW¼	lagoon	6,000	Big Creek	Ogb-5

Table 1. (continued)

Facility Name	Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
Harrisonville, Mo.	T44N R31W S. 5 NE¼	contact stabilization	10,000	Muddy Creek	Oge-7
Peculiar, Mo.	T45N R32W S. 15	lagoon	596	East Branch	Oge-7
Garden City, Mo.	T44N R30W S. 36	2 cell lagoon	812	Panther Creek	Ogb-5
Archie, Mo.	T43N R31W S. 34 NE¼	lagoon	660	Tributary of South Grand River	Og-80
Drexel, Mo.	T43N R33W S. 31 SW¼	lagoon	500	North Sugar Creek	Omdcm-12
Drexel, Mo.	T42N R33W S. 7 NW¼	lagoon	500	North Sugar Creek	Omdcm-12
6. CEDAR COUNTY					
Camp Galilee	T36N R28W S. 22 NW¼	lagoon	53	Walnut Creek	Oc-10
Orleans Trail Public Use Area	T34N R26W S. 22 NE¼	combination activated sludge and extended aeration	---	Stockton Lake	---
Maple Hill Mobile Home Park	T34N R26W S. 14 NE¼	lagoon (2 cell)	172	Bear Creek	Os-35
McKee Mobile Home Park	T34N R26W S. 30 SW¼	lagoon (2 cell)	32	Snag Creek	Osc-20
South Park Mobile Village	T36N R28W S. 33 SW¼	lagoon (2 cell)	119	McCord Branch	Oc-10

Table 1. (continued)

Facility: Name	Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
Stockton State Park	T33N R26W S. 12 SW¼	lagoon	16	Stockton Lake	---
Eldorado Springs, Mo.	T36N R28W S. 17 SW¼	trickling filter plant	7,500	Walnut Creek	Oc-10
Stockton, Mo.	T34N R26W S. 9 SW¼	lagoon (6 acre)	1,200	Stockton Branch	Os-35
Private Landfill	T34N R28W S. 1	uncovered	---	Horse Creek	Os-35
Landfill	T35N R28W S. 15 SE¼	---	---	Alder Creek	Osc-1
Eat-Mo Cheese Co.	T34N R26W S. 9 SW¼	industry	---	Sac River	Os-35
Stockton Lake Dam	T34N R26W S. 10 & 11	periodic low dissolved oxygen & varying water levels	---	Sac River	Os-49
7. COLE COUNTY					
Churchview Heights	T43N R11W S. 20	lagoon (0.25 acre)	57	Rock Creek	O-4
St. Thomas Elderly Housing	T42N R12W S. 23 SW¼	lagoon	10	Profits Creek	O-4
Cole County R-5 School District	T42N R13W S. 19 SE¼	lagoon (0.75 acre)	600	Tavern Creek	O-33
Gravel Operation	T43N R11W S. 29 NE¼	mining & industry	---	Osage River	O-4

Table 1. (continued)

Facility					
Name	Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
8. DADE COUNTY					
Mutton Creek Public Use Area	T32N R26W S. 4 & 9	lagoon	2,500	Stockton Lake	---
Greenfield (North), Mo.	T31N R27W S. 13 SW¼	lagoon	---	Stockton Lake via tributary to Sons Creek	---
Greenfield (West), Mo.	T31N R27W S. 13 SW¼	lagoon (2 cell)	---	Stockton Lake via Sons Creek	---
Greenfield (S.E.), Mo.	T31N R26W S. 19 NW¼	lagoon (2 cell)	---	Tributary to Turnback Creek	Ost-6
Lockwood, Mo.	T31N R28W S. 36 NE¼	activated sludge trickling filter lagoon irrigation	---	Horse Creek	Osch-131
Limestone Quarry	T30N R27W S. 21 NW¼	mining & industry	---	West Fork Limestone Creek	Ostl-3
Limestone Quarry	T31N R27W S. 32 NW¼	mining & industry	---	Sons Creek	Oss-18
Limestone Quarry	T32N R29W S. 24 NW¼	mining & industry	---	Horse Creek	Osch-14
Inactive Stripmine Area	T32, 33N R28, 29W	mining & industry	---	Tributaries to Horse Creek	Osch-14

Table 1. (continued)

Facility					
Name	Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
9. DALLAS COUNTY					
Urbana Coin-o-matic	T36N R20W S. 30 SW¼	lagoon	---	Cahoochie Creek	01n-17
Winchester Gap Subdivision	T36N R18W S. 33 NE¼	lagoon (3 cell)	450	Jakes Creek	On-33
Sand Springs Resort	T35N R18W S. 25 SW¼	lagoon (3 cell)	110	Niangua River	On-33
Jump's Truck Stock	T33N R20W S. 16 NW¼	lagoon	12	Greasy Creek	On-85
Mr. Ed's Drive-in	T36N R20W S. 19 NE¼	lagoon	4	Cahoochie Creek	01n-17
Gem Center No. 1	T32N R20W S. 29 NE¼	lagoon (3 cell)	86	Tributary to Pomme de Terre River	Op-83
Louisburg Lumber, Inc.	T35N R20W S. 21 SE¼	lagoon	12	Ingalls Creek	Pomme de Terre Lake
Buffalo, Mo.	T34N R20W S. 23 NE¼	trickling filter	1,620	Lindley Creek	Opl-63
Bennett Spring State Park	T34N R18W S. 25 NW¼	lagoon with irrigation	---	Niangua River	On-33
A & R Oak Fencing	T33N R18W S. 5 NW¼	penta treated lumber	---	Fourmile Creek	On-33
The Conly Company	T35N R20W S. 14 SW¼	penta treated lumber	---	Thomas Creek	01n-17

Table 1. (continued)

Facility: Name	Facility: Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
Richard Cornett, Rt. 2, Box 89, Elkland, Mo.	T33N R20W S. 23 SE¼	5% penta	---	Greasy Creek	On-85
10. GREENE COUNTY					
Fair Grove Senior Citizen Housing	T31N R20W S. 29 SE¼	lagoon	42	Tributary to Little Pomme de Terre River	Op-83
Willard Laundry	T30N R23W S. 25 SW¼	lagoon	142	Clear Creek	Oscl-1
Walnut Grove Laundry	T31N R24W S. 15 SW¼	lagoon	114	Turkey Creek	---
Fair Haven Children's Home	T29N R20W S. 6 NW¼	lagoon	53	Tributary to South Dry Sac Creek	Osls-98
Sunshine Acres Nursing Home	T29N R22W S. 7 SW¼	lagoon	240	Clear Creek	Oscl-1
Eastgate Motel & Restaurant	T30N R20W S. 35 NE¼	lagoon	37	South Fork of the Pomme de Terre River	Op-83
Cobb's Restaurant	T29N R24W S. 28 SW¼	lagoon	18	Pickering Creek	Os-86
Hood's Service Ctr.	T29N R24W S. 29 SE¼	lagoon	39	Tributary to Pickering Creek	Os-86
Springfield's "44" Auto/Truck Stop, Inc.	T30N R20W S. 34 NE¼	extended aeration	294	Tributary to Little Sac River	---
Lakewood Mobile Home Park	T29N R22W S. 3 NW¼	extended aeration & lagoon	245	Tributary to Dry Sac Creek	Osls-98

Table 1. (continued)

Facility					
Name	Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
Northview Mobile Home Park	T31N R20W S. 20 SE¼	lagoon (3 cell)	112	Pomme de Terre River	Op-83
Willard Elementary School	T30N R23W S. 26 NE¼	sand filter	88	Losing stream tributary to Clear Creek	Oscl-1
Willard High School	T30N R23W S. 26 SE¼	lagoon	141	Losing stream tributary to Clear Creek	Oscl-1
Ash Grove School	T29N R24W S. 1 SW¼	lagoon	103	Tributary to Sac River	Os-86
Fairgrove School	T31N R20W S. 20 NE¼	sand filter	142	Tributary to Pomme de Terre River	Op-83
Ash Grove, Mo.	T30N R24W S. 20 NW¼	trickling filter	1,600	Dry Branch Creek	Os-86
Republic, Mo.	T28N R23W S. 18 NW¼	lagoon (3 cell)	7,500	Dry branch of Pickeral Creek	Os-86
Springfield (Northwest), Mo.	T29N R22W S. 3 NE¼	activated sludge	35,000	Pea Ridge & South Dry Sac Creeks	Osls-98
Landfill	T31N R22W S. 20 SE¼	---	---	Tributary to Little Sac River	Osls-79
Landfill	T30N R22W S. 27 SE¼	inactive	---	Little Sac River	Osls-98
Kerr McGee	T29N R22W S. 9 NE¼	Creosote-Coal for treated railroad ties	---	Clear Creek	Oscl-1

Table 1. (continued)

Facility					
Name	Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
11. HENRY COUNTY					
Winstead's Restaurant	Unknown at this time	lagoon	---	Town Creek	Og-49
Safari Motel	T42N R26W S. 35 SW¼	lagoon	35	Town Creek	Og-49
Montrose School	T40N R28W S. 14 SE¼	lagoon	100	Bear Creek	Ogdb-5
Peabody Coal Co. (Tebo Mine)	T42, 43N R25, 26W	mining	---	Town Creek to Tebo Creek	Ogt-18, Ogtw-3 Ogts-2, Ogtm-3 Ogte-5, Og-17
Peabody Coal Co. (Power Mine)	T40, 41, 42N R27, 28W	mining	---	South Grand River, Deepwater Creek, and Bear Creek	Og-49 Ogd-7 Ogdb-5
Williams Rock	T41N R24W S. 10	mining	---	Tebo Creek	Og-17
Williams Rock	T41N R25W S. 31	mining	---	South Grand River	Og-17
Missouri Public Service Company	T41N R26W S. 10 SW¼	backwash	---	Town Creek	Og-17
Deepwater, Mo.	T40N R26W S. 11 SW¼	trickling filter	700	Deepwater Creek	Og-17
Clinton (Southeast), Mo.	T41N R26W S. 13	lagoon (2 cell)	6,200	Coal Creek	Og-17
Clinton (Southwest), Mo.	T41N R26W S. 15	lagoon (2 cell)	16,960	South Grand River	Og-17
Urich, Mo.	T42N R28W S. 11 NW¼	lagoon	860	South Grand River	Og-49

Table 1. (continued)

Facility Name	Facility Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
Windsor, Mo.	T43N R24W S. 1 NW¼	lagoon	1,700	Elm Branch	Ogte-5
Windsor, Mo.	T43N R24W S. 2 NE¼	lagoon	460	East Fork of Tebo Creek	Ogte-5
Windsor, Mo.	T43N R24W S. 11 SE¼	lagoon	1,810	East Fork of Tebo Creek	Ogte-5
Kansas City Power & Light Company	T41N R28W S. 26,27,35, 36	ash piles	---	Montrose Lake	Ogd-7
12. HICKORY COUNTY					
Wimpey's Laundromat	T36N R21W S. 16	lagoon (no discharge)	11.2	Mill Creek	Op-13
Poulicek Coin-op-laundry	T37N R22W S. 19 SW¼	lagoon	117	Tributary to Little Pomme de Terre River	O-183
Carter-Dretz Subdivision	T37N R23W S. 19 NE¼	lagoon (2 cell)	27	Tributary to Little Pomme de Terre River	O-183
Redbud Mobile Home Park	T36N R22W S. 10 SE¼	lagoon	32	Pomme de Terre Lake	---
Cooper Cove Resort	T36N R22W S. 29 W½	lagoon (2 cell)	65	Pomme de Terre Lake	---
Driftwood Motel	T37N R22W S. 22 SW¼	lagoon	22	Tributary to the Pomme de Terre River	Op-13

Table 1. (continued)

Facility		Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
Name	Location Legal Description				
Gateway Motel, Restaurant & Mobile Home Park	T37N R22W S. 36 SW¼	2 single cell lagoons	53	Mill Creek	Op-13
Golden Dawn Motel	T36N R22W S. 24 NE¼	lagoon	12	Tributary to Pomme de Terre Lake	---
Highway 83 Marina & Resort	T36N R22W S. 33 E½	lagoon	46	Tributary to Pomme de Terre Lake	---
Indian Hill Resort	T36N R22W S. 24 SE¼	lagoon	21	Pomme de Terre Lake	---
King Motel & Pete's Diner	T37N R21W S. 23 SW¼	lagoon	41	Starkes Creek	Oln-17
Lazy E Resort	T36N R22W S. 21 NE¼	lagoon	11	Pomme de Terre Lake	---
Nemo Bridge Resort	T36N R21W S. 18 SW¼	lagoon	17	Tributary to Pomme de Terre Lake	---
Sunflower Resort	T36N R22W S. 10 SW¼	lagoon	19	Tributary to Pomme de Terre Lake	---
Wa-We-Go Resort	T36N R22W S. 9 NW¼	lagoon	35	Pomme de Terre Lake	---
Shultz Service Station	T36N R22W S. 25 SE¼	lagoon	---	Lindley Creek	---
Doorman Trailer Park	T36N R22W S. 4 SW¼	lagoon (2 cell)	69	Tributary to Pomme de Terre Lake	---
R.C. Dryer Mobile Home Park	T36N R21W S. 18 SE¼	lagoon	45	Tributary to Pomme de Terre Lake	---

Table 1. (continued)

Facility						
Name	Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
Galmey Mobile Home Park	T36N R22W S. 9 NE¼	lagoon	51	Tributary to Pomme de Terre Lake	---
Missouri State Park Board	T36N R21W S. 14 NE¼	lagoon	35	Pomme de Terre Lake	---
Damsite Public Use Area	T36N R22W S. 1 NW¼	extended aeration facility	250	Pomme de Terre Lake	---
Lightfoot Public Use Area	T36N R22W S. 33 SW¼	extended aeration facility	---	Pomme de Terre Lake	---
Wheatland Public Use Area	T36N R22W S. 17 NE¼	extended aeration facility	---	Pomme de Terre Lake	---
Hermitage, Mo.	T37N R22W S. 23 S½	lagoon (2 cell)	200	Pomme de Terre River	Op-13
Weaubleau, Mo.	T36N R24W S. 11 NW¼	lagoon	600	South Fork of Weaubleau Creek	Ow-11
Pomme de Terre Dam	T36N R22W S. 2	low dissolved oxygen during discharge periods	---	Pomme de Terre River	Op-27
13. JACKSON COUNTY					
Greenwood Trailer Park	T47N R31W S. unknown	lagoon	180	Big Creek	Ogb-5

Table 1. (continued)

Facility					
Name	Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
Lone Jack School	T47N R30W S. 24 NE¼	lagoon	53	East branch of Crawford Creek	Ogb-5
Prairie Ridge Motel	T47N R31W S. 8 SE¼	septic tank	10	Big Creek	Ogb-5
14. JOHNSON COUNTY					
Leeton, Mo.	T44N R25W S. 20 SE¼	lagoon	395	Wades Creek	Ogts-2
Acid drainage from abandoned & active strip mining	T44N R24W	mining	---	Tebo Creek and its tributaries	Ogte-5, Ogtm-3 Ogts-2, Ogtw-3 Ogt-18
15. LACLEDE COUNTY					
Southern Heights Subdivision	T34N R16W S. 13 NW¼	lagoon	137	Goodwin Hollow	Oad-1
Knapp Senior Citizen's Home	T35N R16W S. 3 NE¼	lagoon	94	Tributary to Goodwin Hollow	Oad-1
Lebanon Holiday Inn	T34N R16W S. 22 NE¼	lagoon (2 cell)	460	Tributary to Goodwin Hollow	Oad-1
Shepherd of the Hills Motel	T34N R16W S. 23 NW¼	lagoon	130	Goodwin Hollow	Oad-1
KOA Campground	T33N R16W S. 5 NE¼	lagoon	10	Goodwin Hollow	Oad-1
B & D Truck Port	T34N R16W S. 22 SE¼	lagoon	22	Goodwin Hollow	Oad-1

Table 1. (continued)

Facility					
Name	Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
McShane Restaurant & Service Station	T32N R17W S. 7 SE¼	lagoon (2 cell)	43	Tributary to Jones Creek	On-105
Truitt's DX Station	T33N R17W S. 22 NW¼	lagoon	15	Dousinbury Creek	On-85
Conway 66 Service Station	T32N R17W S. 7 SE¼	lagoon	99	Tributary to Jones Creek	On-105
Van Stavern Service Station	T34N R16W S. 22 SE¼	lagoon	8	Goodwin Hollow	Oad-1
Interstate Mobile Home Park	T34N R15W S. 6 NW¼	lagoon	48	Dry Auglaize Creek	Oad-1
Monday's Mobile Home Ranch	T34N R16W S. 13 W½	lagoon	58	Dry Auglaize Creek	Oad-1
Oakwood Mobile Home Park	T34N R16W S. 26 SW¼	lagoon (3 cell)	318	Goodwin Hollow	Oad-1
Walnut Meadows Estates Mobile Home Park	T35N R15W S. 30 SW¼	lagoon (3 cell)	141	Dry Auglaize Creek	Oad-1
Webb Mobile Home Park	T34N R16W S. 3 NW¼	lagoon	12	Goodwin Hollow	Oad-1
Laclede Co. C-5 School	T34N R16W S. 7 SW¼	lagoon	90	Goodwin Hollow	Oad-1
Bennett Spring Hatchery	T35N R17W S. 31 SE¼	---	---	Bennett Spring Branch	On-33

Table 1. (continued)

Facility Name	Facility Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
Appleby Manufacturing Company	T34N R16W S. 14 NW¼	---	---	Goodwin Hollow	Oad-1
Lebanon, Mo.	T34N R16W S. 2	trickling filter	7,000	Dry Auglaize	Oad-1
Lebanon, Mo.	T34N R16W S. 4	trickling filter	5,000	Goodwin Hollow	Oad-1
Conway, Mo.	T32N R17W S. 8, SE¼	lagoon (2 cell)	825	Tributary to Jones Creek	On-105
St. Louis & San Francisco Railroad	T34N R16W S. 31 SE¼	burried phosphorus from train wreck	---	Goodwin Hollow	Oad-1
Jennings Bros. Wood Treating Company	T34N R17W S. 24 NE¼	5% penta treating	---	Spring Creek	On-33
Peppers Lumber Company, Inc.	T35N R16W S. 3 SE¼	5% penta treating	---	Goodwin Hollow	Oad-1
Wellman Post Plant	T35N R17W S. 22 NW¼	5% penta treating	---	Mountain Creek	On-33
16. LAWRENCE COUNTY					
Shell Oil Company	T29N R26W S. 12 NE¼	pipeline (have had spills in the past)	---	Turnback Creek	Ost-6

Table 1. (continued)

Facility					
Name	Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
17. MARIES COUNTY					
Vienna, Mo.	T40N R9W S. 19, 30	8.1 acres lagoon (4 cell)	1,360	Fly Creek	Oma-23
18. MILLER COUNTY					
Loc-Wood Boat Dock	T40N R15W S. 18 NE¼	sand filter	---	Osage River	0-78
Lake Ozark Amusement Center	T39N R15W S. 5	lagoons (2)	134	Little Bear Creek	0-67
Lost Dutchman Tavern	T40N R14W S. 10 SW¼	anti-septic extended aeration units	13	Osage River	0-33
Vanosode Laundry Lake Ozark, Mo.	T40N R15W S. 32	lagoon	46	Tributary to the Osage River	0-78
Miller County Court-house, Tuscumbia, Mo.	T40N R14W S. 24 SE¼	lagoon	85	Tributary to Dog Creek	0-33
Senior Manor Corp. St. Elizabeth, Mo.	T41N R12W S. 33 NW¼	lagoon	19	Tavern Creek	Otv-6
Motel (Owner: Harry Dueser)	T40N R15W S. 30	sand filter	30	Lake of the Ozarks	---
Claymont Motor Inn Lake Ozark, Mo.	T40N R15W S. 31 NW¼	lagoon	61	Tributary to Osage River	0-78

Table 1. (continued)

Facility						
Name	Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
Holiday Inn	T40N R15W S. 31 E½	extended aeration treatment plant (3)	440	Lake of the Ozarks	---
Boyd Boots - KOA	T40N R15W S. 16 NW¼	lagoon	40	Osage River	O-67
Rockwood Motel	T40N R15W S. 27 SW¼	lagoon	---	Osage River	O-67
Lady of the Snows Church	T41N R13W S. 15 NW¼	lagoon	61	Tributary to the Osage River	O-33
Lagenberg Hat Co.	T41N R12W S. 32,33	lagoon	10	Tributary to the Osage River	O-33
Bagnell Dam Chamber of Commerce	T40N R15W S. 19 SW¼	lagoon	61	Osage River	O-78
Radio Church of God	T39N R15W S. 5 NW¼	lagoon	132	Osage River	O-67
Donut Shop	T40N R15W S. 19 SE¼	lagoon	10	Lake of the Ozarks	---
Clayton's Restaurant	T40N R15W S. 19 SE¼	sand filter	---	Osage River	O-78
Campbell's Lakehouse	T40N R15W S. 19 SE¼	lagoon	50	Osage River	O-78
Mi-Ho Company	T40N R15W S. 32 NW¼	lagoon	23	Lake of the Ozarks	---
Harry Stewart Restaurant	T40N R15W S. 19 SE¼	lagoon	12	Lake of the Ozarks	---

Table 1. (continued)

Facility					
Name	Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
John King	T39N R15W S. 4	lagoon	66	Little Bear Creek	0-67
Doris' Truck Stop	T41N R15W S. 22 NW¼	lagoon (3 cell)	80	Little Gravois Creek	0-67
El Rancho Resort	T41N R15W S. 15 SE¼	lagoon (2 cell)	29	Saline Creek	0-33
Fisher Trailer Park	T40N R16W S. 12	lagoon (2 cell)	43	Tributaries to Lake of the Ozarks	---
Gaylot Estates Mobile Home Park	T39N R15W S. 4 SE¼	lagoon (2 cell)	32	Bear Creek	0-67
Miller Co. R-2 School District	T40N R15W S. 30 NW¼	sand filter	58	Lake of the Ozarks	---
Eldon, Mo.	T41N R15W S. 3, 4	lagoon	---	Saline Creek	0-33
Gravel operation	T41N R14W S. 16 SE¼	mining	---	Saline Creek	0-33
Gravel operation (2 large)	T40N R15W S. 28 NW¼	mining	---	Osage River	0-78
19. MORGAN COUNTY					
W.W. Whitton (Tavern)	T40N R17W S. 19 NE¼	lagoon	13	Lake of the Ozarks	---

Table 1. (continued)

Facility					
Name	Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
Charles Page (laundry)	T41N R17W S. 29	lagoon	46	Soap Creek	---
Camp Sharon, Church of God	T40N R17W S. 1	lagoon	44	Spring Branch	---
Orval Kent (motel)	T41N R17W S. 20	lagoon	9	Spring Branch	---
Redwood's Resort	T41N R17W S. 36 NW¼	sand filter	20	Lake of the Ozarks	---
Camp Sabra	T40N R16W S. 7 NE¼	lagoon	50	Lake of the Ozarks	---
Miller (Restaurant)	T40N R17W S. 19	lagoon	22	Mill Creek	---
Versailles, Mo.	T43N R17W S. 32	lagoon	190	Little Gravois Creek	---
Versailles, Mo.	T42N R17W S. 5	lagoon	280	Little Gravois Creek	---
Gravel operation	T41N R18W S. 1 SE¼	mining	---	Big Gravois Creek	Ogv-12
Gravel operation	T41N R18W S. 12 SE¼	mining	---	Brushy Creek	Ogv-12
Gravel operation	T41N R17W S. 7 SE¼	mining	---	Big Gravois Creek	---
Gravel operation	T41N R17W S. 8 SW¼	mining	---	Big Gravois Creek	---
Swift Turkey Farm	T40N R17W S. 4 SE¼	---	---	Mill Creek	---

Table 1. (continued)

Facility					
Name	Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
20. OSAGE COUNTY					
Quaker Window Products	T41N R9W S. 16	industry	24	Tributary to the Maries River	Oma-11
Norge Village Freeburg, Mo.	T41N R9W S. unknown	lagoon	40	Tributary to the Maries River	Oma-11
Mrs. James Crockett	T43N R10W S. unknown	lagoon	20	Tributary to the Maries River	Oma-11
Holy Family Church	T41N R9W S. 9 SE¼	lagoon	42	Tributary to the Maries River	Oma-11
Weber Meat Service	T42N R9W S. 8 SW¼	lagoon	600	Bear Creek	O-4
Sunray DX Oil Co.	T43N R10W S. 36 SW¼	undiked oil storage tank	---	Maries River	Oma-11
R.L. Coshow Trailer Park	T43N R10W S. 10 NE¼	lagoon	54	Maries River	O-4
21. PETTIS COUNTY					
No sources identified					

Table 1. (continued)

Facility					
Name	Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
22. POLK COUNTY					
Morrisville Laundry	T32N R23W S. 23 SW¼	lagoon	97	Tributary to the Little Sac River	---
Prairie Heights Subdivision	T33N R23W S. 24 NW¼	lagoon (2 cell)	397	Tributary to Pomme de Terre River	Op-55
Seitz-Mattison Subdivision	T33N R22W S. 30 S½	lagoon (2 cell)	40	Piper Creek	Op-55
Greenview Nursing Home	T33N R23W S. 15 SW¼	lagoon	61	Branch of Bear Creek	Osb-21
Good Samaritan Boy's Ranch	T31N R22W S. 4 SE¼	lagoon	72	Tributary to North Dry Sac River	Osls-79
Stottlemeyer Truck Port	T33N R22W S. 31 SE¼	lagoon (2 cell)	57	Tributary to Piper Creek	Op-55
Braig, Stone, & Craig Mobile Home Park	T32N R24W S. 4 SE¼	lagoon (3 cell)	83	Tributary to Little Sac River	---
Quail Creek Mobile Home Park	T33N R22W S. 29 SW¼	lagoon (3 cell)	333	Branch of Piper Creek	Op-55
Halfway R-3 School	T33N R21W. S. 4 NE¼	lagoon	92	Tributary to Hominy Creek	Op-55
Pleasant Hope Grade School	T32N R21W S. 31 NW¼	septic tank & sand filter	35	Tributary to Pomme de Terre River	Op-55

Table 1. (continued)

Facility					
Name	Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
Pleasant Hope High School	T32N R21W S. 30 NE¼	lagoon	81	Tributary to Pomme de Terre River	Op-55
Bolivar Public Use Area	T35N R22W S. 8	lagoon	---	Pomme de Terre Lake	---
Bolivar, Mo.	T33N R22W S. 6 NW¼	Oxidation ditch	13,410	Tributary to Piper Creek	Op-55
Humansville, Mo.	T35N R24W S. 16 NE¼	lagoon	2,650	Brush Creek	Osbh-3
B.J. Neel Feedlot	T33N R23W S. 16 SE¼	---	---	Bear Creek	Osb-21
Missouri Department of Conservation Forestry Headquarters	T33N R23W S. 10 SE¼	irrigation septic tank	---	Mill Branch	Op-55
23. PULASKI COUNTY					
Lois Abbet	T36N R13W S. 8 NE¼	lagoon	---	Conns Creek	Oaw-10
Crocker, Mo.	T37N R12W S. 7 S½	trickling filter	60	Tavern Creek	Otv-30
Richland, Mo.	T36N R13W S. 7, 18	lagoon	10	Conns Creek	Oaw-10
Dixon, Mo.	T38N R11W S. 23 NW¼	lagoon (10.7 acres)	---	Maries River	Oma-46

Table 1. (continued)

Facility					
Name	Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
24. ST. CLAIR COUNTY					
Fort Scott Fertilizer Quarry	T36N R28W S. 7 SE¼	mining	---	Walnut Creek	Oc-10
Eldridge Addition	T38N R25W S. 29 SE¼	lagoon	29	Tributary to the Osage River	O-208
Hart's Motel & Cafe	T39N R25W S. 19 SW¼	lagoon	38	Big Muddy Creek	O-183
Lake Gate Restaurant	T36N R24W S. 18 NW¼	lagoon	82	West Branch Coon Creek	Os-4
Appleton City, Mo.	T39N R24W S. 4 NW¼	lagoon	1,325	Monegaw Creek	Omg-7
Lowry City, Mo.	T39N R26W S. 24 NW¼	lagoon (2 cell)	812	Gallinipper Creek	O-208
Osceola, Mo.	T38N R25W S. 17 NE¼	contact stabilization	800	Osage River	O-208
Osceola, Mo.	T38N R25W S. 20	raw sewage	---	Tributary to Osage River	O-208
Peabody Coal Co.	T39N R28W	mining	---	Monegaw Creek	Omg-7

Table 1. (continued)

Facility: Name	Facility: Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
25. VERNON COUNTY					
Central States Press, Inc.	T36N R31W S. 27 SW¼	lagoon	40	Sulfur Springs Branch	Om-9
Rolling Meadows Subdivision	T35N R31W S. 17 SW¼	lagoon (2 cell)	240	Little Drywood Creek	Omlw-9
Tally Mobile Home Park	T35N R31W S. 3	lagoon (2 cell)	---	Birch Branch	Om-9
Ponderosa Motel	T35N R21W S. 11 NE¼	septic tank	12	Tributary to West Fork of Clear Creek	Oc-10
Schell City School District R-1	T38N R28W S. 33 SW¼	septic tank with 2 sand filters	30	Miller Branch	O-238
Walker R-4 School	T36N R30W S. 15 NE¼	lagoon	83	Robinson Branch	Oc-10
Camp Clark, National Guard	T35N R30W S. 18	lagoon	8,000	Clear Creek	Oc-10
Nevada State School & Hospital	T36N R31W S. 32 SW¼	activated sludge & trickling filter	---	White Branch	Om-9
Nevada, Mo.	T35N R32W S. 1 T35N R31W S. 6	trickling filter	4,000	Little Drywood Creek	Om-9
Nevada, Mo.	T36N R31W S. 32 NE¼	trickling filter	6,000	White Branch Creek	Om-9

Table 1. (continued)

Facility					
Name	Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
Abandoned strip mine area	T36N R30W	mining	---	Clear Creek	Oc-10
Active strip mine area (company unknown at this time)	T34N R32, 33W	mining	---	Dry Wood Creek	Omw-6
Abandoned strip mine area	T38N R31W	mining	---	Osage River	O-271
Abandoned strip mine area	T37, 38N R33W	mining	---	Little Osage River	Olo-5
Oil drilling sites (Nichols Oil Co.)	T37N R33W S. 34 NW¼	industrial	---	Little Osage River	Olo-5
Oil drilling sites (Shell Oil Co.)	T36N R33W S. 8 SE¼	industrial	---	Marmaton River	Om-24
Oil drilling sites (unknown)	T35N R33W S. 20, 21	industrial	---	Dry Wood Creek	Omw-6
Richhill Rendering Company	T37N R31W S. 17 SW¼	industrial	---	Little Osage River	Olo-4
26. WEBSTER COUNTY					
Fair Oaks Motel	T30N R18W S. 5 SE¼	lagoon	26	Pomme de Terre River	Op-83

Table 1. (continued)

Facility						
Name	Location Legal Description	Type of Facility	Designed Population Equivalent	Receiving Stream	Nearest Sample Site Downstream
Missouri Highway Dept. Rest Area	T32N R18W S. 24 SE¼	lagoon (2 cell)	118	Tributary to Starvey Creek	On-105
Tiny's Country Village	T30N R18W S. 5 NE¼	lagoon (2 cell)	43	Tributary to the Pomme de Terre River	Op-83
Cedarwood Mobile Home Park	T30N R19W S. 31 SW¼	lagoon (3 cell)	48	Tributary to the Pomme de Terre River	Op-83
Gaslight Village Mobile Home Park	T30N R18W S. 5 NE¼	lagoon (2 cell)	52	West Fork of the Niangua River	On-105
Leisure Creek Estates	T31N R18W S. 26 SE¼	lagoon (3 cell)	132	Tributary to East Fork of the Niangua River	On-105
Marshfield, Mo.	T31N R18W S. 33 NE¼ T31N R18W S. 38 SE¼	2 - lagoons	4,108	West Fork of the Niangua River	On-105

[1] Compiled from information obtained from Missouri Clean Water Commission and Missouri Department of Conservation personnel.

Table 2. Invertebrate sampling site locations on the Osage River and its tributaries.

County	Name and Sample Site		Stream Order	Legal Description	Sampling Method[1]	Landmarks
1. Bates						
	Marias des Cygnes	Omdc-24	6	T39N R33W S.2 NW¼	RN or AS	Bates County Route V crossing
	Marais des Cygnes	Omdc-9	7	T38N R31W S.2,11	AS	Bates County Route B crossing
	Miami Creek	Omdcm-12	5	T40W R32W S.24 E½	RN	Highway 52 crossing
	Miami Creek	Omdcm-4	6	T39N R31W S.8 E½	RN	U.S. Highway 71 crossing
	Mulberry Creek	Omdcml-1	4	T40N R33W S.26,35	RN	Bates County road crossing 1 mile south of Highway 52
	Osage River	0-271	8	T38N R29W S.21 S½	AS	Bates County road crossing 2.5 miles SW of Rockville, MO.
2. Benton						
	Turkey Creek	Ot-5	4	T40N R21W S.19,20	RN	At the confluence of White Branch and Turkey creeks
	Deer Creek	Od-6	4	T40N R20W S.31 NE¼	RN	Benton County Route V crossing
	Cole Camp Creek	Occ-11	5	T41N R21W S.10 SW¼	RN	Low water crossing 1 mile east of county Route H
	Big Buffalo Creek	Obb-5	4	T41N R20W S.12,13	RN	Low water crossing 1 mile north of Benton County Route WW

Table 2 (continued).

County	Name and Sample Site		Stream Order	Legal Description	Sampling Method[1]	Landmarks
	Pomme de Terre River	Op-13	6	T39N R22W S.32, 33	RN	Benton County road crossing 1.5 miles north of Avery, MO.
	Osage River	0-183	8	T40N R23W S.2 SE¼	AS	5.5 river miles upstream from U.S. Highway 65
3. Camden						
	Dry Auglaise Creek	Oad-1	5	T38N R15W S.23 NW¼	RN	Camden County Route A crossing
	Wet Auglaise Creek	Oaw-5	5	T38N R14W S.31 W½	RN	Stream crossing on Paul Goforth farm
	Wet Auglaise Creek	Oaw-10	5	T37N R14W S.17 SE¼	RN	Low water crossing 2.5 miles west of Camden County Route A
	Mill Creek	Oawm-1	4	T37N R14W S.18 W½	RN	Low water crossing 1.5 miles east of Highway 7
	Little Niangua River	Oln-17	6	T38N R19W S.14 N½	RN	Low water crossing 0.5 miles north of Camden County Route N
4. Cass						
	South Grand River	Og-80	6	T42N R30W S.11 SE¼	RN	Cass County road crossing 2 miles south of Dayton, MO.
	South Grand River	Og-100	5	T44N R32W S.17 NW¼	AS	Highway 2 crossing
	East Branch of the South Grand River	Oge-7	5	T44N R31W S.18 NW¼	AS	Cass County road crossing 1 mile east of county Route DD

Table 2 (continued).

County	Name and Sample Site		Stream Order	Legal Description	Sampling Method[1]	Landmarks
5. Cedar						
	Horse Creek	Osch-14	5	T34N R28W S.3 SW¼	RN	Cedar County road crossing 0.5 miles south of county Route CC
	Cedar Creek	Osc-1	5	T36N R26W S.30 SW¼	RN	Cedar County road crossing 1.5 miles south of county Route W
	Cedar Creek	Osc-20	4	T34N R27W S.3	RN	Highway 32 crossing
	Sac River	Os-35	6	T35N R26W S.16 SE¼	RN	Cedar County road crossing at Caplinger Mills, MO.
	Sac River	Os-49	6	T34N R26W S.10,11	RN	Highway 32 crossing
	Bear Creek	Osb-8	5	T34N R25W S.10 NE¼	RN	Cedar County Route P crossing
6. Cole						
	Osage River	0-4	8	T44N R10W S.15 SW¼	RN or AS	At Osage City, Mo.
	Osage River	0-33	8	T42N R12W S.1 SE¼	RN or AS	0.75 miles east of Cole County Route B
7. Dade						
	Sons Creek	Oss-11	4	T31N R27W S.4 NE¼	RN	Dade County Route BB crossing
	Sons Creek	Oss-18	3	T31N R27W S.29,32	RN	Highway 160 crossing
	Horse Creek	Osch-131	3	T31N R28W S.23,26	RN	Dade County road crossing 1 mile north of Highway 160

Table 2 (continued).

County	Name and Sample Site		Stream Order	Legal Description	Sampling Method[1]	Landmarks
	Limestone Creek	Ostl-3	4	T31N R26W S.31 SW¼	RN	Low water crossing 0.25 miles east of South Greenfield, MO.
	Turnback Creek	Ost-6	5	T31N R26W S.21 SW¼	RN	Dade County Route O crossing
	Sac River	Os-82	5	T31N R25W S.14 NW¼	RN	Dade County Route U crossing
8. Dallas						
	Bennett Spring	OBS-0	0	T35N R18W S.25,36	RN	First riffle below boil, Bennett Spring State Park
	Niangua River	On-33	5	T36N R18W S.10 SE¼	RN	Just above the confluence of Mill Creek and the Niangua River
	Niangua River	On-85	5	T34N R19W S.17 SW¼	RN	Just below the confluence of Greasy Creek and the Niangua River
	Niangua River	On-105	5	T32N R19W S.2 SE¼	RN	Dallas County Route M crossing
	Lindley Creek	Opl-63	5	T34N R20W S.6	RN	Low water crossing 1 mile north of Dallas County Route Z
	Little Niangua River	Oln-132	4	T36N R19W S.6 SW¼	RN	Low water crossing 1.5 miles west of Dallas County Route PP
9. Greene						
	Little Sac River	Osls-98	4	T30N R22W S.28,29	RN	Low water crossing 1 mile south of Green County Route O

Table 2 (continued).

County	Name and Sample Site		Stream Order	Legal Description	Sampling Method[1]	Landmarks
	Little Sac River	Osls-103	3	T30N R22W S.26 SW¼	RN	Highway 13 crossing
	Sac River	Os-86	5	T30N R24W S.6 SW¼	RN	Low water crossing 2 miles west of Greene County Route V
	Clear Creek	Oscl-1	4	T31N R24W S.31,32	RN	Low water crossing 1 mile west of Greene County Route V
10. Henry						
	South Grand River	Og-49	6	T41N R26W S.17 SE¼	RN	Henry County road crossing 2 miles SW of Clinton, MO.
	South Grand River	Og-17	6	T40N R24W S.10 NW¼	RN	Henry County road crossing at French's bridge
	Deepwater Creek	Ogd-7	5	T40N R26W S.2,3	RN	Highway Spur 52 crossing
	South Deepwater Creek	Ogds-1	4	T40N R28W S.8 W½	RN	Henry County road crossing 1.5 miles north of Route H
	Big Creek	Ogb-5	6	T42N R27W S.15,16,21,22	AS	Highway 7 crossing
	Bear Creek	Ogdb-5	4	T40N R27W S.8 SE¼	RN	Strip mine haul road crossing 1 mile north of Highway 52, 2.5 miles east of Montrose, MO.
	Tebo Creek	Ogt-18	5	T42N R24W S.30 NW¼	RN	Henry County road crossing 1.5 miles west of Route V
	West Fork of Tebo Creek	Ogtw-3	3	T42N R25W S.14,15,22,23	RN	Henry County road crossing 1.5 miles north of Route Y Y

Table 2 (continued).

County	Name and Sample Site		Stream Order	Legal Description	Sampling Method[1]	Landmarks
	Sand Creek	Ogts-2	4	T42N R25W S.12 SW¼	RN	Henry County road crossing 1 mile SW of Route V
	Middle Fork of Tebo Creek	Ogtm-3	4	T43N R24W S.19 NE¼	RN	Henry County road crossing 1.5 miles north of Calhoun, MO.
	East Fork of Tebo Creek	Ogte-5	4	T43N R24W S.27 SE¼	RN	Henry County road crossing 1 mile north of Route OO and 1 mile west of Route Y
11. Hickory						
	Pomme de Terre River	Op-27	6	T37N R22W S.35 SW¼	RN	2.5 river miles downstream from Pomme de Terre Dam
12. Maries						
	Maries River	Oma-23	4	T41N R10W S.26 SE¼	RN	Maries County Route AA crossing
	Maries River	Oma-29	4	T40N R10W S.13 SE¼	RN	Low water crossing 2 miles NW of Vienna, MO.
	Maries River	Oma-46	3	T38N R10W S.18 NW¼	RN	Low water crossing 1.5 miles SW of Shantytown, MO.
	Little Maries River	Omal-3	4	T40N R10W S.4 NE¼	RN	Maries County Route T crossing
13. Miller						
	Osage River	O-67	8	T40N R14W S.10,15	RN or AS	0.5 miles upstream from Tuscumbia Access Area

Table 2 (continued).

County	Name and Sample Site		Stream Order	Legal Description	Sampling Method[1]	Landmarks
	Osage River	O-78	8	T40N R15W S.21 NE¼	RN or AS	2 river miles downstream from U.S. Highway 54
	Tavern Creek	Otv-6	5	T41N R12W S.22 SE¼	RN	Highway 52 crossing
	Tavern Creek	Otv-30	5	T39N R12W S.9 SW¼	RN	0.5 miles north of Highway 42 at Brays Mill
14. Morgan						
	Gravois Creek	Ogv-17	4	T42N R18W S.34 NW¼	RN	Low water crossing 3.5 miles west of Highway 5
	Gravois Creek	Ogv-12	4	T41N R17W S.7 NW¼	RN	Highway 5 crossing
15. Osage						
	Maries River	Oma-11	4	T43N R10W S.35 NE¼	RN	U.S. Highway 63 crossing
16. Polk						
	Lindley Creek	Opl-46	5	T35N R21W S.9,16	RN	Low water crossing 0.5 miles west of Polk County Route HH
	Pomme de Terre River	Op-55	5	T34W R23W S.1 SW¼	RN	Low water crossing 0.25 miles south of Polk County Route NN
	Pomme de Terre River	Op-83	5	T32N R21W S.21,22	RN	Low water crossing 0.5 miles west of Polk County Route Z
	Little Sac River	Osls-79	5	T32N R23W S.33 SW¼	RN	Low water crossing 1 mile east of Polk County Route JJ

Table 2 (continued).

County	Name and Sample Site		Stream Order	Legal Description	Sampling Method[1]	Landmarks
	Bear Creek	Osb-21	4	T33N R24W S.13,14	RN	Low water crossing 1.5 miles north of Polk County Route WW
17. St. Clair						
	Osage River	O-238	8	T38N R25W S.31 W½	AS	0.5 miles upstream from the mouth of the Sac River
	Osage River	O-208	8	T39N R24W S.4 NE¼	RN	At Grapevine Access Area
	Weaubleau Creek	Ow-11	4	T37N R24W S.18 NE¼	RN	Low water crossing 0.25 miles west of St. Clair County Route T
	Sac River	Os-4	6	T37N R26W S.1 SE¼	AS	At Highway 82 crossing
	Brush Creek	Osbh-3	5	T36N R25W S.20	RN	Low water crossing 0.5 miles SE of St. Clair County Route J
	Monegaw Creek	Omg-7	5	T38N R27W S.7,8,17,18	RN	St. Clair County Route B crossing
	Clear Creek	Oc-10	6	T37N R28W S.29	RN or AS	County road crossing 2 miles west of St. Clair County Route H
18. Vernon						
	Little Osage River	Olo-5	5	T37N R31W S.18 SW¼	RN	County road crossing 1 mile of U.S. Highway 71
	Little Osage River	Olo-4	5	T37N R31W S.17 NW¼	RN	U.S. Highway 71 crossing

Table 2 (continued).

County	Name and Sample Site		Stream Order	Legal Description	Sampling Method[1]	Landmarks
	Little Dry Wood Creek	Omlw-9	5	T35N R31W S.31 NE¼	RN	Low water crossing 1.25 miles north of Vernon County Route F
	Dry Wood Creek	Omw-6	6	T35N R33W S.24,25	RN	Vernon County Route KK crossing
	Marmaton River	Om-24	6	T35N R33W S.2 NE¼	RN	Low water crossing 0.75 miles north of U.S. Highway 54
	Marmaton River	Om-9	7	T36N R31W S.8,17	RN	Vernon County road crossing 1 mile west of U.S. Highway 71

[1] RN - Riffle Net
AS - Artificial Substrate

Table 4. Taxonomic list of fishes collected from the Osage River and its tributaries (Pflieger 1975).

Common and scientific names	Osage River (mainstem)	Minor Mainstem Tributaries	Marais des Cygnes River	Marmaton-Little Osage River	South Grand River	Sac River	Pomme de Terre River	Niangua River
Family: Petromyzontidae-Lampreys								
Northern brook lamprey								
Ichthyomyzon fossor								X
Chestnut lamprey								
Ichthyomyzon castaneus	X	X				X	X	X
Family: Acipenseridae-Sturgeons								
Lake sturgeon								
Acipenser fulvescens	X							
Shovelnose sturgeon								
Scaphirhynchus platorynchus	*							
Family: Polyodontidae-Paddlefishes								
Paddlefish								
Polyodon spathula	X		*	X	X	*		
Family: Lepisosteidae-Gars								
Shortnose gar								
Lepisosteus platostomus	*		X					
Longnose gar								
Lepisosteus osseus	X	X	X	*	X	X	X	X
Family: Anguillidae-Eels								
American eel								
Anguilla rostrata	X	*						
Family: Clupeidae-Herrings								
Skipjack herring								
Alosa chrysochloris	X							
Alabama shad								
Alosa alabamae	X							
Gizzard shad								
Dorosoma cepedianum	X	X	X	X	X	X	X	X

Table 4. Continued.

Common and scientific names	Osage River (mainstem)	Minor Mainstem Tributaries	Marais des Cygnes River	Marmaton-Little Osage River	South Grand River	Sac River	Pomme de Terre River	Niangua River
Threadfin shad Dorosoma petenense					X			
Family: Hiodontidae-Mooneyes								
Goldeye Hiodon alosoides	X		*	*	*	*	*	*
Mooneye Hiodon tergisus	*	X	*	*	*	X	*	X
Family: Salmonidae-Trouts								
Rainbow trout Salmo gairdneri		X						X
Brown trout Salmo trutta								X
Family: Esocidae-Pikes								
Northern pike Esox lucius	X	X				X		
Muskellunge Esox masquinongy							X	X
Family: Cyprinidae-Minnows								
Carp Cyprinus carpio	X	X	*	X	X	*	X	X
Goldfish Carassius auratus	*	X	*	*	*	*	*	*
Grass Carp Ctenopharyngodon idella	*							
Golden shiner Notemigonus crysoleucas	*	X	X	X	X	*	*	X
Creek chub Semotilus atromaculatus	*	X	*	*	X	X	X	X

Table 4. Continued.

Common and scientific names	Osage River (mainstem)	Minor Mainstem Tributaries	Marais des Cygnes River	Marmaton-Little Osage River	South Grand River	Sac River	Pomme de Terre River	Niangua River
Southern redbelly dace *Phoxinus erythrogaster*		X				X	X	X
Hornyhead chub *Nocomis biguttatus*	X	X	X	X	X	X	X	X
Silver chub *Hybopsis storeriana*	X	X	*	*	X	*	*	*
Gravel chub *Hybopsis x-punctatus*	X	X				X	X	X
Speckled chub *Hybopsis aestivalis*	X					*	*	
Suckermouth minnow *Phenacobius mirabilis*	X	X	X	X	X	X	X	
Emerald shiner *Notropis atherinoides*	X		X		X	*	*	*
Rosyface shiner *Notropis rubellus*	X	X				X	X	X
Redfin shiner *Notropis umbratilis*	X	X	X	X	X	X	X	X
Bleeding shiner *Notropis zonatus*		X				X	X	X
Striped shiner *Notropis chrysocephalus*					X	X	X	X
Wedgespot shiner *Notropis greenei*		X						X
Red shiner *Notropis lutrensis*	X	X	X	X	X	X	X	X

Table 4. Continued.

Common and scientific names	Osage River (mainstem)	Minor Mainstem Tributaries	Marais des Cygnes River	Marmaton-Little Osage River	South Grand River	Sac River	Pomme de Terre River	Niangua River
Sand shiner <u>Notropis stramineus</u>	X	X	X	X	X	X	X	X
Blacknose shiner <u>Notropis heterolepis</u>		X						
Mimic shiner <u>Notropis volucellus</u>	X							
Ghost shiner <u>Notropis buchanani</u>	X	X	X	X		X		
Ozark minnow <u>Dionda nubila</u>	*	X				X	X	X
Western silvery minnow <u>Hybognathus argyritis</u>	X	X						
Bluntnose minnow <u>Pimephales notatus</u>	X	X	X	X	X	X	X	X
Fathead minnow <u>Pimephales promelas</u>	*	X	X	X	X	*	X	*
Central stoneroller <u>Campostoma anomalum</u>	*	X	*	X	X	X	X	X
Largescale stoneroller <u>Campostoma oligolepis</u>	*	X				X	X	X
Family: Catostomidae-Suckers								
Blue sucker <u>Cycleptus elongatus</u>	X							
Bigmouth buffalo <u>Ictiobus cyprinellus</u>	X	*	X	X	X	*	X	*
Black buffalo <u>Ictiobus niger</u>	X		*	*	*	*	*	*

Table 4. Continued.

Common and scientific names	Osage River (mainstem)	Minor Mainstem Tributaries	Marais des Cygnes River	Marmaton-Little Osage River	South Grand River	Sac River	Pomme de Terre River	Niangua River
Smallmouth buffalo *Ictiobus bubalus*	X		X	*	X	*	X	*
River carpsucker *Carpiodes carpio*	X	*	X	X	X	*	X	*
Highfin carpsucker *Carpiodes velifer*	*	*				*	X	X
Quillback *Carpiodes cyprinus*	X	*			*	*	X	X
White sucker *Catostomus commersoni*	*	X	X	X	X	X	X	X
Northern hog sucker *Hypentelium nigricans*	*	X				X	X	X
Black redhorse *Moxostoma duquesnei*	*	X				X	X	X
Golden redhorse *Moxostoma erythrurum*	X	X	X			X	X	X
Silver redhorse *Moxostoma anisurum*	*	X				X	*	X
Shorthead redhorse *Moxostoma macrolepidotum*	X	X	*	*	*	X	X	X
River redhorse *Moxostoma carinatum*	X	*				X	X	X
Family: Ictaluridae-Catfishes								
Black bullhead *Ictalurus melas*	X	X	X	X	X	*	X	X

Table 4. Continued.

Common and scientific names	Osage River (mainstem)	Minor Mainstem Tributaries	Marais des Cygnes River	Marmaton-Little Osage River	South Grand River	Sac River	Pomme de Terre River	Niangua River
Yellow bullhead *Ictalurus natalis*	*	X	X	X	X	X	X	X
Channel catfish *Ictalurus punctatus*	X	X	X	X	X	X	X	X
Blue catfish *Ictalurus furcatus*	X		*	*	X	*	*	*
Tadpole madtom *Noturus gyrinus*	*	X	X	X	X	*		
Freckled madtom *Noturus nocturnus*	X	X	X	X	*	X	X	*
Slender madtom *Noturus exilis*	*	X	*	X	X	X	X	X
Stonecat *Noturus flavus*	X	*	*	X	X	X	X	X
Flathead catfish *Pylodictus olivaris*	X	X	X	X	X	X	*	X
Family: Percopsidae-Trout-perches								
Trout-perch *Percopsis omiscomaycus*	*							
Family: Amblyopsidae-Cavefishes								
Southern cavefish *Typhlichthys subterraneus*		X				X	*	X

Table 4. Continued.

Common and scientific names	Osage River (mainstem)	Minor Mainstem Tributaries	Marais des Cygnes River	Marmaton-Little Osage River	South Grand River	Sac River	Pomme de Terre River	Niangua River
Family: Cyprinodontidae-Killifishes								
Northern studfish								
Fundulus catenatus	X	X				X	X	X
Plains topminnow								
Fundulus sciadicus	X	X						X
Blackspotted topminnow								
Fundulus olivaceus	X	X			*	X	X	X
Blackstripe topminnow								
Fundulus notatus	*	X	*	X				
Family: Poeciliidae-Livebearers								
Mosquitofish								
Gambusia affinis	X	X	*	X				
Family: Atherinidae-Silversides								
Brook silversides								
Labidesthes sicculus	X	X		X	*	X	X	X
Mississippi silversides								
Menidia audens						X		
Family: Cottidae-Sculpins								
Mottled sculpin								
Cottus bairdi	X	X			X	*	X	
Banned sculpin								
Cottus carolinae	X	X				X	*	X
Family: Percichthyidae-Seabasses								
White bass								
Morone chrysops	X	*					X	*
Striped bass								
Morone saxatilis	*	X						X

Table 4. Continued.

Common and scientific names	Osage River (mainstem)	Minor Mainstem Tributaries	Marais des Cygnes River	Marmaton-Little Osage River	South Grand River	Sac River	Pomme de Terre River	Niangua River
Family: Centrarchidae								
Smallmouth bass *Micropterus dolomieui*	X	X				X	X	X
Spotted bass *Micropterus punctatus*	X	X				X	X	X
Largemouth bass *Micropterus salmoides*	X	X	X	X	X	X	X	X
Warmouth *Lepomis gulosus*	*	X	*	X				
Green sunfish *Lepomis cyanellus*	X	X	X	X	X	X	X	X
Orangespotted sunfish *Lepomis humilis*	X	X	X	X	X	X	X	X
Longear sunfish *Lepomis megalotis*	X	X		X		X	X	X
Bluegill *Lepomis macrochirus*	X	X	*	X	X	X	X	X
Rock bass *Ambloplites rupestris*	*	X						X
Ozark Rock bass *Ambloplites constellatus*						X		
White crappie *Pomoxis annularis*	X	X	X	X	X	X	X	X
Black crappie *Pomoxis nigromaculatus*	X	*	*	*	*	*	X	X
Family: Percidae-Perches								
Walleye *Stizostedion vitreum*	X	X	X	*	*	X	X	X

Table 4. Continued.

Common and scientific names	Osage River (mainstem)	Minor Mainstem Tributaries	Marais des Cygnes River	Marmaton-Little Osage River	South Grand River	Sac River	Pomme de Terre River	Niangua River
Sauger Stizostedion canadense	X	*						
Bluestripe darter Percina cymatotaenia								X
Slenderhead darter Percina phoxocephala	X	X	X	X	X	X	X	X
Logperch Percina caprodes	X	X	*	*	*	X	X	X
Gilt darter Percina evides	X	*						
Johnny darter Etheostoma nigrum	*	X	*	*	X	*	*	X
Bluntnose darter Etheostoma chlorosomum		X						
Missouri saddled darter Etheostoma tetrazonum	X	X				X	X	X
Banded darter Etheostoma zonale	*	X				X	X	X
Greenside darter Etheostoma blennioides	*	X				X	X	X
Niangua darter Etheostoma nianguae		X				X	X	X
Stippled darter Etheostoma punctulatum	X	X				X	X	X

Table 4. Continued.

Common and scientific names	Osage River (mainstem)	Minor Mainstem Tributaries	Marais des Cygnes River	Marmaton-Little Osage River	South Grand River	Sac River	Pomme de Terre River	Niangua River
Rainbow darter Etheostoma caeruleum	*	X				X	X	X
Orangethroat darter Etheostoma spectabile	*	X	*	X	X	X	X	X
Fantail darter Etheostoma flabellare	X	X	*	X	*	X	X	X
Slough darter Etheostoma gracile		*						
Least darter Etheostoma microperca		X						X
Family: Sciaenidae-Drums								
Freshwater drum Aplodinotus grunniens	X	X	X	*	X	*	X	X

X - Represented in fish collections.

* - Not represented in fish collections, but within distribution range.

Table 5. Taxonomic list of benthic macroinvertebrates identified in samples collected from the Osage River and its tributaries, 1975-76.

Classification [1]	Osage River (mainstem)	Minor Mainstem Tributaries	Marais des Cygnes River	Marmaton-Little Osage Rivers	South Grand River	Sac River	Pomme de Terre River	Niangua River
Phylum: Arthropoda								
Class: Insecta								
Order: Plecoptera								
Family: Pteronarcidae								
Pteronarcys sp.		X						X
Family: Taeniopterygidae								
Taeniopteryx sp.	X	X	X	X	X	X	X	X
Strophopteryx fasciata		X				X	X	X
Family: Nemouridae								
Amphinemura/*Prostoia*	X	X			X	X	X	X
Family: Leuctridae								
Leuctra sp.	X	X						X
Perlomyia sp.						X		
Family: Capniidae								
Allocapnia ozarkana	X	X	X	X	X	X	X	X
A. granulata						X		
Capnia sp.								X
Family: Perlidae								
Acroneuria arida		X			X	X	X	X
Neoperla sp.	X	X	X		X	X	X	X
Paragnetina sp.		X				X	X	X
Phasganophora sp.		X				X	X	
Perlesta placida	X	X	X	X	X	X	X	X
Perlinella drymo		X	X					
Family: Perlodidae								
Isogenus sp.		X	X		X	X	X	X
Isoperla bilineata/*richardsoni*	X	X	X	X	X	X	X	X
I. mohri		X						

Table 5. Continued.

Classification[1]	Osage River (mainstem)	Minor Mainstem Tributaries	Marais des Cygnes River	Marmaton-Little Osage River	South Grand River	Sac River	Pomme de Terre River	Niangua River
Family: Chloroperlidae								
Hastaperla sp.	X	X			X	X	X	X
Order: Ephemeroptera								
Family: Siphlonuridae								
Isonychia sp.	X	X	X	X	X	X	X	X
Family: Baetidae								
Baetis sp.	X	X	X	X	X	X	X	X
B. intercalaris			X					
Callibaetis sp.	X		X		X	X		
Pseudocloeon sp.	X	X	X	X	X	X	X	X
Family: Heptageniidae								
Cinygma sp.			X					
Heptagenia sp.	X	X	X	X	X	X	X	X
Rhithrogena sp.		X				X	X	X
Stenacron interpunctatum	X	X	X	X	X	X	X	X
Stenonema terminatum		X		X	X			
S. femoratum	X	X	X	X	X	X	X	X
S. mediopunctatum	X	X			X	X	X	X
S. pulchellum	X	X	X	X	X	X	X	X
S. integrum	X							
S. quinquespinum		X	X			X		
Family: Ephemerellidae								
Ephemerella bicolor		X				X	X	X
E. serrata		X				X		X
E. invaria		X				X		X
E. needhami		X				X	X	X
E. deficiens								
E. serratoides		X						X
E. dorothea/excrucians		X				X	X	X
E. lutulenta	X	X				X	X	X
E. minimella		X						
E. argo		X						
E. simplex						X		X

Table 5. Continued.

Classification[1]	Osage River (mainstem)	Minor Mainstem Tributaries	Marais des Cygnes River	Marmaton-Little Osage River	South Grand River	Sac River	Pomme de Terre River	Niangua River
E. lita								X
E. temporalis		X				X		X
Family: Tricorythidae								
Tricorythodes sp.	X	X	X	X	X	X	X	X
Family: Caenidae								
Caenis sp.	X	X	X	X	X	X	X	X
Family: Baetiscidae								
Baetisca lacustris		X				X		X
Family: Leptophlebiidae								
Choroterpes sp.	X	X	X					X
Leptophlebia sp.	X	X				X	X	X
Paraleptophlebia sp.	X	X	X			X		X
Family: Potamanthidae								
Potamanthus sp.	X	X				X	X	X
Family: Ephemeridae								
Ephemera varia		X	X			X	X	X
E. guttalata						X		
Hexagenia limbata	X	X	X		X	X		X
Family: Polymitarcyidae								
Ephoron album	X	X				X		X
E. leukon						X		X
Tortopus sp.			X					
Order: Trichoptera								
Family: Philopotamidae								
Chimarra obscura	X	X	X	X	X	X	X	X
C. aterrima		X			X	X	X	X
Wormaldia sp.		X						X

Table 5. Continued.

Classification[1]	Osage River (mainstem)	Minor Mainstem Tributaries	Marais des Cygnes River	Marmaton-Little Osage River	South Grand River	Sac River	Pomme de Terre River	Niangua River
Family: Psychomyiidae								
Lype diversa		X						
Psychomyia flavida	X					X	X	X
Psychomyiid Genus A	X		X	X	X	X		
Family: Polycentropodidae								
Cyrnellus sp.	X	X	X	X	X	X		
Neureclipsis sp.	X		X			X		
Polycentropus sp.	X	X	X	X	X	X		X
Family: Hydropsychidae								
Cheumatopsyche sp.	X	X	X	X	X	X	X	X
Hydropsyche arinale						X		
H. betteni	X	X	X	X	X	X	X	
H. cuanis	X	X	X	X	X	X	X	X
H. frisoni	X		X		X			
H. orris	X		X	X	X			
H. scalaris						X		
H. simulans	X	X	X	X	X			
Potamyia flava	X	X	X	X	X			
Symphitopsyche alhedra						X		
S. bifida		X				X	X	X
Family: Rhyacophilidae								
Rhyacophila sp.	X	X	X	X	X	X	X	X
Family: Glossosomatidae								
Agapetus sp.	X	X			X	X	X	X
Family: Hydroptilidae								
Agraylea sp.	X	X	X	X	X	X	X	X
Hydroptila sp.	X	X	X	X	X	X	X	X
Ochrotrichia sp.	X	X	X	X	X	X	X	X
Neotrichia sp.			X					

Table 5. Continued.

Classification[1]	Osage River (mainstem)	Minor Mainstem Tributaries	Marais des Cygnes River	Marmaton-Little Osage River	South Grand River	Sac River	Pomme de Terre River	Niangua River
Family: Brachycentridae								
Brachycentrus americanus							X	
B. lateralis		X			X			X
Micrasema sp.		X						
Family: Lepidostomatidae								
Lepidostoma sp.		X						X
Family: Limnephilidae								
Neophylax sp.		X			X	X	X	X
Pseudostenophylax sp.		X			X	X	X	
Hesperophylax sp.	X							
Limnephilus sp.		X						
Family: Helicopsychidae								
Helicopsyche borealis		X				X	X	X
Family: Leptoceridae								
Leptocerus sp.	X	X		X	X	X	X	X
Ceraclea alagmus		X		X		X	X	X
Mystacides sp.		X						X
Nectopsyche sp.						X		
Oecetis sp.	X	X	X	X	X	X	X	
Order: Coleoptera								
Family: Gyrinidae								
Dineutes sp.	X	X	X	X	X	X		
Gyretes sp.			X		X			
Gyrinus sp.			X		X			
Family: Haliplidae								
Peltodytes tortulosus				X		X		

Table 5. Continued.

Classification[1]	Osage River (mainstem)	Minor Mainstem Tributaries	Marais des Cygnes River	Marmaton-Little Osage River	South Grand River	Sac River	Pomme de Terre River	Niangua River
Family: Dytiscidae								
Agabinus sp.					X			
Deronectes/Oreodytes					X	X		
Dytiscus sp.	X	X	X			X		
Hydroporus undulatus		X	X		X			
H. niger			X		X			
Laccophilus fasciatus	X		X					
L. proximus			X					
Family: Hydrophilidae								
Ametor sp.			X					
Berosus sp.	X	X	X	X	X	X	X	
Crenitis sp.	X							
Enochrus sp.		X						
Helochares sp.					X			
Helophorus sp.				X	X			
Hydrobius sp.					X			
Hydrophilus sp.	X		X		X	X	X	
Paracymus sp.			X		X			
Family: Psephenidae								
Ectopria nervosa		X				X	X	X
Psephenus herricki		X	X			X	X	X
Family: Dryopidae								
Helichus lithophilus	X	X				X	X	X
Family: Helodidae								
Elodes sp.	X	X	X	X	X	X		
Family: Elmidae								
Ancyronyx sp.	X	X				X	X	
Dubiraphia sp.	X	X	X	X	X	X	X	X
Macronychus sp.	X	X	X	X	X	X	X	X
Optioservus sandersoni	X	X		X		X	X	X
Stenelmis sp.	X	X	X	X	X	X	X	X
Family: Limnichidae								
Lutrochus sp.		X				X	X	

Table 5. Continued.

Classification[1]	Osage River (mainstem)	Minor Mainstem Tributaries	Marais des Cygnes River	Marmaton-Little Osage River	South Grand River	Sac River	Pomme de Terre River	Niangua River
Family: Curculionidae								
Endalus sp.					X			
Onychylis sp.	X				X			
Stenopelmus rufinosus	X	X	X					
Family: Heteroceridae			X		X			
Order: Diptera								
Family: Tipulidae								
Tipula sp.	X	X	X		X	X	X	X
Antocha sp.		X				X		X
Erioptera sp.	X	X	X	X	X	X	X	
Hexatoma sp.		X		X	X	X	X	X
Dicranota sp.		X				X		
Family: Culicidae								
Aedes sp.					X			
Anopheles sp.	X				X			
Mansonia perturbans					X			
Family: Chaoboridae								
Chaoborus sp.	X	X	X	X	X		X	
Family: Psychodidae								
Pericoma sp.		X				X		
Psychoda sp.						X		
Family: Ceratopogonidae								
Forcipomyia sp.					X	X		
Bezzia/Probezzia	X	X	X	X	X	X	X	X
Culicoides sp.		X				X		
Alluaudomyia sp.		X						
Family: Simuliidae								
Simulium sp.	X	X	X	X	X	X	X	X
Family: Chironomidae	X	X	X	X	X	X	X	X

Table 5. Continued.

Classification[1]	Osage River (mainstem)	Minor Mainstem Tributaries	Marais des Cygnes River	Marmaton-Little Osage River	South Grand River	Sac River	Pomme de Terre River	Niangua River
Family: Tanyderidae								
Protoplasa sp.		X						
Family: Stratiomyidae								
Euparyphus sp.	X	X	X		X			X
Family: Tabanidae								
Chrysops sp.	X	X	X		X	X	X	X
Family: Athericidae								
Atherix lantha		X				X		X
Family: Empididae								
Roederiodes sp.	X	X	X	X	X	X	X	X
Family: Syrphidae								
Chrysogaster sp.	X	X						
Family: Ephydridae	X	X	X	X	X	X		
Family: Muscidae								
Limnophora sp.	X	X	X	X	X	X	X	X
Order: Odonata								
Family: Gomphidae								
Erpetogomphus designatus	X	X					X	
Gomphus (*G.*) *vastus*	X	X	X	X	X	X	X	X
G. (*G.*) *externus*						X		
G. (*G.*) *fraternus*						X		
Lanthus sp.		X						
Progomphus obscurus		X						
Family: Aschnidae								
Anax junius	X							
Nasiaeschna pentacantha					X			

Table 5. Continued.

Classification[1]	Osage River (mainstem)	Minor Mainstem Tributaries	Marais des Cygnes River	Marmaton-Little Osage River	South Grand River	Sac River	Pomme de Terre River	Niangua River
Family: Macromiidae								
Macromia sp.	X				X	X		
Family: Corduliidae								
Tetragoneuria cynosura	X							
Family: Libellulidae								
Brachymesia fuscata	X							
Erythemis simplicoris	X							
Libellula sp.	X					X		
Plathemis lydia	X							
Family: Calopterygidae								
Calopteryx maculatum					X			
Hetaerina americana	X	X			X	X	X	
Family: Coenagrionoidae		X	X			X		X
Argia moesta	X	X	X	X	X	X	X	X
A. sedula/violacea	X	X	X		X			
A. tibialis/apicalis	X	X	X	X	X			
Enallagma praevarum	X	X			X	X		
Nehalennia sp.			X					
Order: Megaloptera								
Family: Sialidae								
Sialis sp.	X	X	X	X	X	X	X	X
Family: Corydalidae								
Corydalus cornutus	X	X	X	X	X	X	X	X
Nigronia serricornus	X	X	X			X		X
Order: Neuroptera								
Family: Sisyridae								
Climacia areolaris			X			X		

Table 5. Continued.

Classification[1]	Osage River (mainstem)	Minor Mainstem Tributaries	Marais des Cygnes River	Marmaton-Little Osage River	South Grand River	Sac River	Pomme de Terre River	Niangua River
Order: Hemiptera								
Family: Veliidae								
Microvelia sp.		X			X	X	X	
Rhagovelia sp.				X	X	X	X	X
Family: Gerridae								
Gerris sp.		X						
Rheumatobates sp.		X		X	X	X		
Trepobates sp.	X	X			X			
Family: Nepidae								
Ranatra sp.					X			
Family: Corixidae	X	X	X	X	X	X		
Family: Notonectidae								
Notonecta sp.		X						
Family: Mesoveliidae								
Mesovelia sp.						X		
Family: Saldidae	X	X	X					
Order: Lepidoptera								
Family: Pyralidae								
Nymphula sp.			X					
Parargyractis sp.		X	X		X	X	X	X
MISCELLANEOUS GROUPS								
Phylum: Annelida								
Class: Hirudinea								
Family: Glossiphoniidae	X	X	X	X	X	X	X	X

Table 5. Continued.

Classification[1]	Osage River (mainstem)	Minor Mainstem Tributaries	Marais des Cygnes River	Marmaton-Little Osage River	South Grand River	Sac River	Pomme de Terre River	Niangua River
Class: Oligochaeta								
Family: Branchiobdellidae		X		X	X	X		X
Other Oligochaetes	X	X	X	X	X	X	X	X
Phylum: Mollusca								
Class: Gastropoda								
Order: Basommatophora								
Family: Physidae								
Physa sp.	X	X	X	X	X	X		X
Family: Lymnaeidae								
Lymnaea sp.	X	X	X		X	X		X
Family: Planorbidae	X	X	X	X	X	X	X	X
Family: Ancylidae								
Ferrissia sp.	X	X	X	X	X	X	X	X
Order: Mesogastropoda								
Family: Bulimidae								
Amnicola sp.	X							
Family: Pleuroceridae								
Goniobasis sp.	X	X				X	X	X
Family: Viviparidae	X	X				X		
Class: Pelecypoda								
Order: Heterodonta								
Family: Sphaeriidae	X	X	X	X	X	X	X	X
Family: Corbiculidae								
Corbicula leana	X	X						
Order: Eulamellibranchia								
Family: Unionidae[2]								
Anodonta grandis grandis		X		X*	X*		X*	
A. imbecillus						X*		

Table 5. Continued.

Classification[1]	Osage River (mainstem)	Minor Mainstem Tributaries	Marais des Cygnes River	Marmaton-Little Osage River	South Grand River	Sac River	Pomme de Terre River	Niangua River
Strophitus undulatus undulatus		X				X	X	X
Alasmidonta marginata						X		
A. viridis						X*		X
Arcidens confragosus***						X		
Lasmigona complanata	X*	X*		X	X*			
L. costata		X*				X*		X*
Megalonaias nervosa	X*				X*	X*		
Tritogonia verrucosa	X*		X*	X*	X*	X	X*	
Quadrula quadrula	X*	X*		X*	X*	X*		
Q. metanevra	X					X		
Q. pustulosa	X	X*	X*	X*	X	X	X*	X*
Amblema plicata plicata	X	X*	X*	X*	X*	X*	X*	X*
Fusconaia flava	X*	X*	X*	X*	X*	X*	X*	X*
Cyclonaias tuberculata	X*					X*		
Pleurobema coccineum	X*	X*	X*	X*		X*	X*	
Elliptio dilatata	X*	X	X*	X*		X	X	X*
Uniomerus tetralasmus**					X*			
Obliquaria reflexa	X						X*	
Actinonaias ligamentina carinata	X*	X	X*		X	X*	X*	X*
Venustaconcha ellipsiformis ellipsiformis	X*	X				X	X	X*
Plagiola lineolata						X*	X*	
Truncilla truncata					X*	X	X	X*
T. donaciformis				X	X	X*	X*	
Leptodea fragilis	X	X	X*	X*	X	X*	X	X*
Potamilus alatus	X*	X*		X*	X*	X*	X*	X*
Toxolasma parvus						X*		
Ligumia recta		X*				X*		
L. subrostrata						X*		
Lampsilis teres teres		X*				X*		
L. radiata luteola		X			X*	X	X*	X*
L. ventricosa	X*	X			X*	X*	X*	X
L. reeviana brittsi						X	X	X

Table 5. Continued.

Classification[1]	Osage River (mainstem)	Minor Mainstem Tributaries	Marais des Cygnes River	Marmaton-Little Osage River	South Grand River	Sac River	Pomme de Terre River	Niangua River
Phylum: Arthropoda								
Class: Crustacea								
Order: Amphipoda								
Family: Gammaridae								
Crangonyx minor		X				X	X	X
Gammarus pseudolimnaeus	X	X	X			X	X	X
Family: Talitridae								
Hyalella azteca	X	X	X	X	X	X	X	X
Order: Isopoda								
Family: Asellidae								
Asellus sp.	X	X			X	X		X
Lirceus sp.	X	X	X	X	X	X	X	X
Order: Decapoda								
Family: Astacidae								
Orconectes putnami	X	X	X	X	X	X	X	X
O. merchandi		X	X	X	X	X	X	X
O. spinosus				X				
Class: Arachnoidea								
Order: Acari	X	X	X	X	X	X	X	X
Phylum: Nemata	X	X	X	X	X	X	X	X
Phylum: Nematomorpha								
Class: Gordiida	X	X		X	X	X	X	X
Phylum: Platyhelminthes								
Class: Turbellaria								
Order: Tricladida								
Family: Planariidae	X	X	X	X	X	X	X	X

1 Classification follows Merritt and Cummins (1978) and Ward & Whipple (1959).

2 Naiad classification follows David Stansbery, Ohio State University Museum of Zoology, Columbus, Ohio.

* Present as dead shell material only
** Rare in Missouri
*** Endangered in Missouri

APPENDIX A

Appendix Table A-1. Chemical parameters analyzed at selected invertebrate sampling sites on the mainstem Osage River, 1973-75.

Parameter	O-33			
Source	U.S.G.S.(1975)	U.S.G.S.(1975)	U.S.G.S.(1975)	U.S.G.S.(1975)
Date	10-18-74	2-13-75	4-17-75	6-4-75
Water Temperature (^{o}C)	18.5	2.0	11.0	18.0
Discharge (cfs)	7,740	31,000	9,080	10,100
Dissolved oxygen*	6.0	10.4	8.8	6.8
Percent oxygen saturation (%)	63	75	80	71
pH	7.9	8.2	8.1	7.8
Colour (Platinum Cobalt Units)	--	--	--	--
Specific Conductance (µmhos/cm@ 25^{o}C)	268	327	313	300
Fecal Coliform (colonies/100ml)	60	40	4	50
Streptococci (colonies/100ml)	90	84	12	440
Turbidity (Jackson Turbidity Units)	--	--	--	--
Chemical Oxygen Demand*	--	--	--	--
Alkalinity as $CaCO_3$*	100	100	118	118
Calcium Hardness*	--	--	--	--
Magnesium Hardness*	--	--	--	--
Total Hardness*	120	130	140	140
Nitrate Nitrogen*	--	--	--	--
Ammonia Nitrogen*	--	--	--	--
Total Organic Nitrogen*	--	--	--	--
Total Phosphorus*	0.07	0.09	0.06	0.03
Ortho Phosphorus*	--	--	--	--
Calcium*	36	42	39	39
Magnesium*	8.3	11.0	9.9	11.0
Sodium*	5.6	6.3	6.0	5.0
Potassium*	2.9	2.1	2.3	1.9
Iron*	--	--	--	--
Manganese*	--	--	--	--
Sulfate*	35	35	31	28
Chloride*	5.0	4.9	6.0	4.9
Fluoride*	0.1	0.2	0.1	0.1
Silicone Dioxide*	4.8	6.2	4.7	4.2
Non-filterable solids*	166	170	180	182
Organic Carbon*	--	5.2	--	--
Secchi Disc (cm)	--	--	--	--

* expressed as mg/l

Appendix Table A-1. Continued.

Parameter	0-183	0-208	0-271
Source	Kersh(1977)	Kersh(1977)	Kersh(1977)
Date	8-28-73	8-28-73	8-22-73)
Water Temperature (^{o}C)	29.0	29.0	28.5
Discharge (cfs)	--	--	--
Dissolved oxygen*	7.6	7.5	12.0
Percent oxygen saturation (%)	97	97	155
pH	7.8	--	7.8
Colour (Platinum Cobalt Units)	--	--	--
Specific Conductance (μmhos/cm@ 25^{o}C)	350	270	444
Fecal Coliform (colonies/100 ml)	--	180	30
Streptococci (colonies/ 100 ml)	--	50	50
Turbidity (Jackson Turbidity Units)	--	--	9.0
Chemical Oxygen Demand*	11.0	0.0	16.0
Alkalinity as $CaCO_3$*	160	--	190
Calcium Hardness*	--	--	--
Magnesium Hardness*	--	--	--
Total Hardness*	--	--	--
Nitrate Nitrogen*	0.4	0.3	0.6
Ammonia Nitrogen*	0.2	0.2	0.5
Total Organic Nitrogen*	--	--	--
Total Phosphorus*	0.30	0.14	0.17
Ortho Phosphorus*	0.08	0.04	0.07
Calcium*	--	--	--
Magnesium*	--	--	--
Sodium*	8.0	1.8	--
Potassium*	3.4	1.4	--
Iron*	0.4	<0.1	<0.1
Manganese*	<1.0	<1.0	<1.0
Sulfate*	30	<10	52
Chloride*	0.7	5.1	0.6
Fluoride*	0.64	0.30	0.27
Silicone Dioxide*	--	--	13.5
Non-filterable solids*	--	--	--
Organic Carbon*	--	--	--
Secchi Disc (cm)	42	--	33

* expressed as mg/l

Appendix Table A-2. Chemical parameters analyzed at selected invertebrate sampling sites on minor mainstem tributaries to the Osage River, 1973.

Parameters	Ow-11	Omg-7	Oc-10
Source	Kersh(1977)	Kersh(1977)	Kersh(1977)
Date	8-21-73	8-22-73	8-22-73
Water Temperature (°C)	25.0	21.5	30.0
Discharge (cfs)	--	--	--
Dissolved oxygen*	6.2	6.9	11.0
Percent oxygen saturation (%)	72	77	145
pH	7.0	--	7.2
Colour (Platinum Cobalt Units)	--	--	--
Specific Conductance (μmhos/cm@ 25°C)	300	1400	220
Fecal Coliform (colonies/100 ml)	--	--	480
Streptococci (colonies /100 ml)	--	--	50
Turbidity (Jackson Turbidity Units)	8.0	15.0	7.0
Chemical Oxygen Demand*	5.1	19.0	16.0
Alkalinity as $CaCO_3$*	170	--	90
Calcium Hardness*	--	--	--
Magnesium Hardness*	--	--	--
Total Hardness*	--	--	--
Nitrate Nitrogen*	<0.1	<0.1	<0.1
Ammonia Nitrogen*	0.1	0.2	0.3
Total Organic Nitrogen*	--	--	--
Total Phosphorus*	0.09	0.08	0.27
Ortho Phosphorus*	0.02	0.03	0.08
Calcium*	--	--	--
Magnesium*	--	--	--
Sodium*	3.1	--	12.5
Potassium*	3.3	--	14.8
Iron*	<0.1	<0.1	0.7
Mangenese*	1.0	1.7	<1.0
Sulfate*	12	625	15
Chloride*	0.5	0.4	1.3
Fluoride*	0.22	0.21	0.59
Silicone Dioxide*	11.7	5.6	--
Non-filterable solids*	--	--	--
Organic Carbon*	--	--	--
Secchi Disc (cm)	--	--	--

* expressed as mg/l

Appendix Table A-3. Chemical parameters analyzed at selected invertebrate sampling sites on the Marais des Cygnes River and Miami Creek. 1973-75.

Parameter	Omdc-9	Omdc-24	
Source	Kersh(1977)	U.S.G.S.(1975)	U.S.G.S.(1975)
Date	8-23-73	10-7-74	2-4-75
Water Temperature (^oC)	28.0	16.0	3.0
Discharge (cfs)	--	107	5,150
Dissolved oxygen*	8.4	8.7	11.4
Percent oxygen saturation (%)	106	88	84
pH	8.3	8.1	7.8
Colour (Platinum Cobalt Units)	--	5	20
Specific Conductance (µmhos/cm@ 25^oC)	380	482	418
Fecal Coliform (colonies/100 ml)	30	90	1,400
Streptococci (colonies/100 ml)	40	100	3,000
Turbidity (Jackson Turbidity Units)	22	--	--
Chemical Oxygen Demand*	14	12	32
Alkalinity as $CaCO_3$*	163	207	143
Calcium Hardness*	--	--	--
Magnesium Hardness*	--	--	--
Total Hardness*	--	190	100
Nitrate Nitrogen*	0.6	9.8	1.5
Ammonia Nitrogen*	0.60	0.04	0.01
Total Organic Nitrogen*	--	0.67	1.00
Total Phosphorus*	0.37	0.16	0.50
Ortho Phosphorus*	0.06	0.04	0.07
Calcium	--	76	58
Magnesium*	--	10.0	6.2
Sodium*	15.7	13.0	9.0
Potassium*	3.7	3.0	3.0
Iron*	1.2	--	--
Manganese*	<1.0	--	--
Sulfate*	40	37	42
Chloride*	0.7	10.0	7.4
Fluoride*	0.92	0.30	0.20
Silicone Dioxide*	--	5.4	8.0
Non-filterable solids*	--	278	241
Organic Carbon*	--	--	--
Secchi Disc (cm)	--	--	--

* expressed as mg/l

Appendix Table A-3. Continued.

Parameter	Omdc-24		Omdcm-4
Source	U.S.G.S.(1975)	U.S.G.S.(1975)	Kersh(1977)
Date	4-2-75	6-11-75	8-23-73
Water Temperature (^{o}C)	7.0	20.0	25.0
Discharge(cfs)	2,720	9,010	--
Dissolved oxygen*	11.2	5.1	2.9
Percent oxygen saturation(%)	93	55	33
pH	7.9	7.6	6.6
Colour (Platinum Cobalt Units)	60	65	--
Specific Conductance (µmhos/cm@ 25^{o}C)	418	243	280
Fecal Coliform (colonies/100 ml)	210	11,000	2,100
Streptococci (colonies/100 ml)	740	43,000	1,700
Turbidity (Jackson Turbidity Units)	--	--	--
Chemical Oxygen Demand*	28	86	42
Alkalinity as $CaCO_3$*	162	84	118
Calcium Hardness*	--	--	--
Magnesium Hardness*	--	--	--
Total Hardness*	190	100	--
Nitrate Nitrogen*	9.8	1.5	0.1
Ammonia Nitrogen*	0.04	0.01	0.20
Total Organic Nitrogen*	0.83	3.90	--
Total Phosphorus*	0.16	0.50	0.80
Ortho Phosphorus*	0.04	0.07	0.27
Calcium*	64	34	--
Magnesium*	8.4	4.2	--
Sodium*	11.0	6.5	10.0
Potassium*	2.5	2.9	5.6
Iron*	--	--	5.1
Manganese*	--	--	3.4
Sulfate*	38	19	21
Chloride*	8.8	3.9	0.8
Fluoride*	0.30	0.20	0.93
Silicone Dioxide*	6.8	6.3	--
Non-filterable solids*	254	140	--
Organic Carbon*	--	--	--
Secchi Disc (cm)	--	--	--

* expressed as mg/l

Appendix Table A-4. Chemical parameters analyzed at selected invertebrate sampling sites on the Marmaton and Little Osage rivers. 1973-75.

Parameters	Om-9			
Source	Kersh(1977)	Kersh(1977)	Kersh(1977)	Kersh(1977)
Date	8-23-73	4-4-74	4-11-74	4-18-74
Water Temperature (^{o}C)	25.5	13.5	14.0	16.0
Discharge (cfs)	--	--	--	--
Dissolved oxygen*	4.6	8.8	9.5	8.8
Percent oxygen saturation (%)	55	83	91	88
pH	7.7	7.7	7.4	7.3
Colour (Platinum Cobalt Units)	--	--	--	--
Specific Conductance (μmhos/cm@ 25^{o}C)	1,150	850	1,050	1,100
Fecal Coliform (colonies/100 ml)	20	--	--	--
Streptococci (colonies/100 ml)	<10	--	--	--
Turbidity (Jackson Turbidity Units)	32	13	6	18
Chemical Oxygen Demand*	20	--	--	--
Alkalinity as $CaCO_3$*	180	--	--	--
Calcium Hardness*	--	--	--	--
Magnesium Hardness*	--	--	--	--
Total Hardness*	--	--	--	--
Nitrate Nitrogen*	<0.1	0.1	0.1	<0.1
Ammonia Nitrogen*	0.1	0.1	0.1	0.2
Total Organic Nitrogen*	--	--	--	--
Total Phosphorus*	0.52	0.07	0.23	0.09
Ortho Phosphorus*	0.26	0.06	0.00	0.00
Calcium*	--	93	114	117
Magnesium*	--	37.4	42.7	45.6
Sodium*	100.0	15.8	24.6	11.6
Potassium*	--	--	--	--
Iron*	1.00	1.33	0.84	1.24
Manganese*	<1.00	0.63	0.47	0.52
Sulfate*	250	300	580	480
Chloride*	3.9	--	--	--
Fluoride*	0.91	--	--	--
Silicone Dioxide*	--	--	--	--
Non-filterable solids*	--	300	700	1,474
Organic Carbon*	--	--	--	--
Secchi Disc (cm)	--	--	--	--

* expressed as mg/l

Appendix Table A-4. Continued.

Parameter	Om-9			
Source	Kersh(1977)	Kersh(1977	Kersh(1977)	Kersh(1977)
Date	4-24-74	5-2-74	5-9-74	5-16-74
Water Temperature (^{o}C)	18.5	18.0	--	22.0
Discharge (cfs)	--	--	--	--
Dissolved oxygen*	9.3	7.2	7.6	5.6
Percent oxygen saturation (%)	98	75	--	63
pH	7.1	7.1	7.7	7.3
Colour (Platinum Cobalt Units)	--	--	--	--
Specific Conductance (μmhos/cm@ 25^{o}C)	910	720	--	395
Fecal Coliform (colonies/100 ml)	--	--	--	--
Streptococci (colonies/100 ml)	--	--	--	--
Turbidity (Jackson Turbidity Units)	10	60	26	110
Chemical Oxygen Demand*	--	--	--	--
Alkalinity as $CaCO_3$*	--	--	--	--
Calcium Hardness*	--	--	--	--
Magnesium Hardness*	--	--	--	--
Total Hardness*	--	--	--	--
Nitrate Nitrogen*	0.1	0.1	0.3	1.1
Ammonia Nitrogen*	0.1	0.1	0.2	0.2
Total Organic Nitrogen*	--	--	--	--
Total Phosphorus*	0.18	0.29	0.26	0.35
Ortho Phosphorus*	0.08	0.12	0.15	0.18
Calcium*	115	92	100	58
Magnesium*	41.8	26.8	32.2	9.1
Sodium*	11.3	15.4	26.8	5.5
Potassium*	--	--	--	--
Iron*	1.25	2.39	1.64	3.75
Manganese*	0.71	0.71	1.48	0.70
Sulfate*	380	240	370	80
Chloride*	--	--	--	--
Fluoride*	--	--	--	--
Silicone Dioxide*	--	--	--	--
Non-Filterable solids*	508	1,525	3,565	2,499
Organic Carbon*	--	--	--	--
Secchi Disc (cm)	--	--	--	--

* expressed as mg/1

Appendix Table A-4. Continued.

Parameter	Om-9			
Source	Kersh(1977)	Kersh(1977)	Kersh(1977)	Kersh(1977)
Date	5-23-74	5-30-74	3-8-75	3-24-75
Water Temperature (^{o}C)	23.5	24.5	7.5	13.0
Discharge (cfs)	--	--	--	--
Dissolved oxygen*	5.1	6.4	10.4	8.8
Percent oxygen saturation (%)	58	75	86	82
pH	7.2	7.4	8.3	7.5
Colour (Platinum Cobalt Units)	--	--	--	--
Specific Conductance (μmhos/cm@ 25^{o}C)	600	1,000	300	585
Fecal Coliform (colonies/100 ml)	--	--	--	--
Streptococci (colonies/100 ml)	--	--	--	--
Turbidity (Jackson Turbidity Units)	55	34	72	30
Chemical Oxygen Demand*	--	--	--	--
Alkalinity as $CaCO_3$*	--	--	78	125
Calcium Hardness*	--	--	38	82
Magnesium Hardness*	--	--	9	21
Total Hardness*	--	--	132	292
Nitrate Nitrogen*	0.9	0.7	0.9	0.4
Ammonia Nitrogen*	0.2	0.2	0.2	0.1
Total Organic Nitrogen*	--	--	--	--
Total Phosphorus*	0.24	0.26	0.19	0.12
Ortho Phosphorus*	0.22	0.20	0.04	0.06
Calcium*	74	112	--	--
Magnesium*	21.1	42.2	--	--
Sodium*	0.7	23.2	6.2	15.0
Potassium*	--	--	--	--
Iron*	3.33	2.00	0.30	0.10
Manganese*	0.64	0.71	<1.0	<1.0
Sulfate*	200	140	96	210
Chloride*	--	--	--	--
Fluoride*	--	--	--	--
Silicone Dioxide*	--	--	--	--
Non-filterable solids*	641	319	150	75
Organic Carbon*	--	--	--	--
Secchi Disc (cm)	--	--	--	--

* expressed as mg/l

Appendix Table A-4. Continued.

Parameter	Om-9			
Source	Kersh(1977)	Kersh(1977)	Kersh(1977)	Kersh(1977)
Date	3-31-75	4-7-75	4-14-75	4-21-75
Water Temperature (^{o}C)	7.0	11.0	12.0	16.5
Discharge (cfs)	--	--	--	--
Dissolved oxygen*	10.3	9.5	9.3	8.5
Percent oxygen saturation (%)	84	85	85	86
pH	8.2	8.4	8.0	7.9
Colour (Platinum Cobalt Units)	--	--	--	--
Specific Conductance (µmhos/cm@ 25^{o})	310	625	740	700
Fecal Coliform (colonies/100 ml)	--	--	--	--
Streptococci (colonies/100 ml)	--	--	--	--
Turbidity (Jackson Turbidity Units)	75	26	22	19
Chemical Oxygen Demand*	--	--	--	--
Alkalinity as $CaCO_3$*	90	138	146	150
Calcium Hardness*	41	90	98	98
Magnesium Hardness*	11	18	31	32
Total Hardness*	148	300	376	376
Nitrate Nitrogen*	0.6	0.4	0.1	<0.1
Ammonia Nitrogen*	<0.1	0.1	0.1	<0.1
Total Organic Nitrogen*	--	--	--	--
Total Phosphorus*	0.21	0.10	0.11	0.16
Ortho Phosphorus*	0.20	<0.02	0.03	0.03
Calcium*	--	--	--	--
Magnesium*	--	--	--	--
Sodium*	5.0	11.6	13.9	12.6
Potassium*	--	--	--	--
Iron*	0.2	0.1	0.1	0.2
Manganese*	<1.0	<1.0	<1.0	<1.0
Sulfate*	157	126	260	300
Chloride*	--	--	--	--
Fluoride*	--	--	--	--
Silicone Dioxide*	--	--	--	--
Non-filterable solids*	140	55	25	45
Organic Carbon*	--	--	--	--
Secchi Disc (cm)	--	--	--	--

* expressed as mg/l

Appendix Table A-4. Continued.

Parameter	Om-9			
Source	Kersh(1977)	Kersh(1977)	Kersh(1977)	Kersh(1977)
Date	4-28-75	5-5-75	5-12-75	5-19-75
Water Temperature (^{o}C)	21.0	19.5	22.0	24.0
Discharge (cfs)	--	--	--	--
Dissolved oxygen*	5.8	7.2	6.3	6.6
Percent oxygen saturation (%)	64	77	71	77
pH	7.6	7.7	7.8	8.0
Colour (Platinum Cobalt Units)	--	--	--	--
Specific Conductance (μmhos/cm@ 25^{o}C)	440	680	760	1,000
Fecal Coliform (colonies/100 ml)	--	--	--	--
Streptococci (colonies/100 ml)	--	--	--	--
Turbidity (Jackson Turbidity Units)	83	49	38	33
Chemical Oxygen Demand*	--	--	--	--
Alkalinity as $CaCO_3$*	98	120	150	162
Calcium Hardness*	58	96	97	124
Magnesium Hardness*	13	24	36	49
Total Hardness*	200	338	384	514
Nitrate Nitrogen*	0.4	0.3	0.5	0.3
Ammonia Nitrogen*	0.1	0.4	0.2	0.1
Total Organic Nitrogen*	--	--	--	--
Total Phosphorus*	0.26	0.45	0.22	0.19
Ortho Phosphorus*	0.06	0.04	0.02	0.04
Calcium*	--	--	--	--
Magnesium*	--	--	--	--
Sodium*	6.8	11.4	3.0	17.1
Potassium*	--	--	--	--
Iron*	0.3	0.2	0.3	0.2
Manganese*	<1.0	<1.0	<1.0	<1.0
Sulfate*	154	250	240	306
Chloride*	--	--	--	--
Fluoride*	--	--	--	--
Silicone Dioxide*	--	--	--	--
Non-filterable solids*	250	130	125	80
Organic Carbon*	--	--	--	--
Secchi Disc (cm)	--	--	--	--

* expressed as mg/l

Appendix Table A-4. Continued.

Parameter	Om-9	Om-24	Olo-5
Source	Kersh(1977)	Kersh(1977)	Kersh(1977)
Date	5-26-75	8-23-75	8-23-75
Water Temperature (^{o}C)	21.5	25.0	29.5
Discharge (cfs)	--	--	--
Dissolved oxygen*	5.5	3.3	4.9
Percent oxygen saturation (%)	62	35	64
pH	7.0	7.3	7.4
Colour (Platinum Cobalt Units)	--	--	--
Specific Conductance (µmhos/cm@ 25^{o}C)	670	530	400
Fecal Coliform (colonies/100 ml)	--	30	60
Streptococci (colonies/100 ml)	--	230	80
Turbidity (Jackson Turbidity Units)	63	10	47
Chemical Oxygen Demand*	--	19	19
Alkalinity as $CaCO_3$*	64	250	190
Calcium Hardness*	78	--	--
Magnesium Hardness*	34	--	--
Total Hardness*	336	--	--
Nitrate Nitrogen*	1.9	<0.1	0.1
Ammonia Nitrogen*	0.2	0.1	0.2
Total Organic Nitrogen*	--	--	--
Total Phosphorus*	0.54	0.38	0.33
Ortho Phosphorus*	<0.02	0.25	0.11
Calcium*	--	--	--
Magnesium*	--	--	--
Sodium*	15.6	21.5	9.0
Potassium*	--	3.9	7.8
Iron*	0.7	1.3	1.2
Manganese*	<1.0	<1.0	2.9
Sulfate*	380	30	34
Chloride*	--	1.0	0.9
Fluoride*	--	0.74	0.88
Silicone Dioxide*	--	--	--
Non-filterable solids*	570	--	--
Organic Carbon*	--	--	--
Secchi Disc (cm)	--	33	--

* expressed as mg/l

Appendix Table A-5. Chemical parameters analyzed at selected invertebrate sampling sites on the South Grand River and its tributaries. 1973-75.

Parameter	Og-17			
Source	Kersh(1977)	Kersh(1977)	Kersh(1977)	Kersh(1977)
Date	8-21-73	4-5-74	4-12-74	4-19-74
Water Temperature (^{o}C)	30.0	12.5	14.0	15.5
Discharge (cfs)	--	--	--	--
Dissolved oxygen*	10.5	9.0	9.1	14.4
Percent oxygen saturation (%)	137	83	88	145
pH	7.5	8.0	6.2	7.6
Colour (Platinum Cobalt Units)	--	--	--	--
Specific Conductance (μmhos/cm@ 25^{o}C)	420	550	490	540
Fecal Coliform (colonies/100 ml)	10	--	--	--
Streptococci (colonies/100 ml)	60	--	--	--
Turbidity (Jackson Turbidity Units)	10	8	33	20
Chemical Oxygen Demand*	7.9	--	--	--
Alkalinity as $CaCO_3$*	158	--	--	--
Calcium Hardness*	--	--	--	--
Magnesium Hardness*	--	--	--	--
Total Hardness*	--	--	--	--
Nitrate Nitrogen*	<0.1	0.1	0.3	<0.1
Ammonia Nitrogen*	0.10	0.1	0.1	<0.1
Total Organic Nitrogen*	--	--	--	--
Total Phosphorus*	0.08	0.16	0.21	0.13
Ortho Phosphorus*	0.02	0.04	0.00	0.00
Calcium*	--	69.9	58.4	68.8
Magnesium*	--	16.8	13.0	15.4
Sodium*	10.9	2.9	4.2	1.4
Potassium*	4.6	--	--	--
Iron*	<0.10	1.26	1.28	0.63
Manganese*	<1.00	0.17	0.23	0.21
Sulfate*	60	115	90	115
Chloride*	0.4	--	--	--
Fluoride*	0.26	--	--	--
Silicone Dioxide*	8.4	--	--	--
Non-filterable solids*	--	25	35	13
Organic Carbon*	--	--	--	--
Secchi Disc (cm)	57	--	--	--

* expressed as mg/l

Appendix Table A-5. Continued.

Parameter	Og-17			
Source	Kersh(1977)	Kersh(1977)	Kersh(1977)	Kersh(1977)
Date	4-26-74	5-3-74	5-9-74	5-17-74
Water Temperature (^{o}C)	18.0	18.0	--	21.5
Discharge (cfs)	--	--	--	--
Dissolved oxygen*	9.0	6.5	7.4	5.9
Percent oxygen saturation (%)	94	68	--	66
pH	7.2	7.5	7.4	7.4
Colour (Platinum Cobalt Units)	--	--	--	--
Specific Conductance (μmhos/cm@ 25^{o}C)	555	380	--	210
Fecal Coliform (colonies/100 ml)	--	--	--	--
Streptococci (colonies/100 ml)	--	--	--	--
Turbidity (Jackson Turbidity Units)	11	90	145	180
Chemical Oxygen Demand*	--	--	--	--
Alkalinity as $CaCO_3$*	--	--	--	--
Calcium Hardness*	--	--	--	--
Magnesium Hardness*	--	--	--	--
Total Hardness*	--	--	--	--
Nitrate Nitrogen*	<0.1	0.9	0.9	1.6
Ammonia Nitrogen*	<0.1	1.1	1.1	0.2
Total Organic Nitrogen*	--	--	--	--
Total Phosphorus*	0.16	0.21	0.48	0.25
Ortho Phosphorus*	0.02	0.21	0.27	0.25
Calcium*	76.8	51.2	74.4	29.6
Magnesium*	15.4	12.0	10.6	4.8
Sodium*	5.9	12.8	13.5	0.3
Potassium*	--	--	--	--
Iron*	0.75	3.36	5.88	5.76
Manganese*	0.33	0.59	1.78	0.60
Sulfate*	110	45	120	31
Chloride*	--	--	--	--
Fluoride*	--	--	--	--
Silicone Dioxide*	--	--	--	--
Non-filterable solids*	35	115	470	475
Organic Carbon*	--	--	--	--
Secchi Disc (cm)	--	--	--	--

* expressed as mg/l

Appendix Table A-5. Continued.

Parameter	Og-17			
Source	Kersh(1977)	Kersh(1977)	Kersh(1977)	Kersh(1977)
Date	5-24-74	5-31-74	3-19-75	3-25-75
Water Temperature (°C)	23.0	23.0	8.0	9.5
Discharge (cfs)	--	--	--	--
Dissolved oxygen*	5.0	6.5	10.4	9.5
Percent oxygen saturation (%)	57	74	87	83
pH	6.4	--	8.3	9.2
Colour (Platinum Cobalt Units)	--	--	--	--
Specific Conductance (μmhos/cm@ 25°C)	230	360	300	415
Fecal Coliform (colonies/100 ml)	--	--	--	--
Streptococci (colonies/100 ml)	--	--	--	--
Turbidity (Jackson Turbidity Units)	120	41	80	37
Chemical Oxygen Demand*	--	--	--	--
Alkalinity as $CaCO_3$	--	--	96	160
Calcium Hardness*	--	--	40	60
Magnesium Hardness*	--	--	7	12
Total Hardness*	--	--	130	198
Nitrate Nitrogen*	0.9	1.5	0.9	0.8
Ammonia Nitrogen*	0.1	0.1	0.2	0.1
Total Organic Nitrogen*	--	--	--	--
Total Phosphorus*	0.26	0.25	0.24	0.13
Ortho Phosphorus*	0.20	0.14	0.08	0.10
Calcium*	31.2	60.0	--	--
Magnesium*	4.8	9.6	--	--
Sodium*	0.3	3.8	2.7	5.9
Potassium*	--	--	--	--
Iron*	4.50	1.47	0.30	0.10
Manganese*	0.19	0.09	<1.00	<1.00
Sulfate*	33	90	6	75
Chloride*	--	--	--	--
Fluoride*	--	--	--	--
Silicone Dioxide*	--	--	--	--
Non-filterable solids*	100	25	270	65
Organic Carbon*	--	--	--	--
Secchi Disc (cm)	--	--	--	--

* expressed as mg/l

Appendix Table A-5. Continued.

Parameter	Og-17			
Source	Kersh(1977)	Kersh(1977)	Kersh(1977)	Kersh(1977)
Date	4-1-75	4-8-75	4-15-75	4-22-75
Water Temperature (°C)	7.0	10.0	11.0	16.2
Discharge (cfs)	--	--	--	--
Dissolved oxygen*	10.2	9.9	9.2	8.8
Percent oxygen saturation (%)	83	87	83	89
pH	7.9	7.8	7.8	8.0
Colour (Platinum Cobalt Units)	--	--	--	--
Specific Conductance (μmhos/cm@ 25°C)	265	370	400	495
Fecal Coliform (colonies/100 ml)	--	--	--	--
Streptococci (colonies/100 ml)	--	--	--	--
Turbidity (Jackson Turbidity Units)	80	58	61	22
Chemical Oxygen Demand*	--	--	--	--
Alkalinity as $CaCO_3$*	84	122	125	155
Calcium Hardness*	38	59	64	71
Magnesium Hardness*	8	10	9	13
Total Hardness*	130	190	198	232
Nitrate Nitrogen*	0.8	0.7	0.4	0.1
Ammonia Nitrogen*	<0.1	0.1	<0.1	<0.1
Total Organic Nitrogen*	--	--	--	--
Total Phosphorus*	0.18	0.16	0.14	0.16
Ortho Phosphorus*	0.09	0.04	0.07	0.03
Calcium*	--	--	--	--
Magnesium*	--	--	--	--
Sodium*	5.2	2.2	7.9	7.2
Potassium*	--	--	--	--
Iron*	0.2	0.1	0.1	0.2
Manganese*	<1.0	<1.0	<1.0	<1.0
Sulfate*	91	28	60	120
Chloride*	--	--	--	--
Fluoride*	--	--	--	--
Silicone Dioxide*	--	--	--	--
Non-filterable solids*	180	100	85	40
Organic Carbon*	--	--	--	--
Secchi Disc (cm)	--	--	--	--

* expressed as mg/l

Appendix Table A-5. Continued.

Parameter	Og-17			
Source	Kersh(1977)	Kersh(1977)	Kersh(1977)	Kersh(1977)
Date	4-29-75	5-6-75	5-13-75	5-20-75
Water Temperature (^{o}C)	20.5	20.5	22.0	23.7
Discharge (cfs)	--	--	--	--
Dissolved oxygen*	5.7	7.3	7.2	7.1
Percent oxygen saturation (%)	62	80	81	82
pH	7.5	7.9	8.0	8.0
Colour (Platinum Cobalt Units)	--	--	--	--
Specific Conductance (µmhos/cm@ 25^{o}C)	260	440	450	500
Fecal Coliform (colonies/100 ml)	--	--	--	--
Streptococci (colonies/100 ml)	--	--	--	--
Turbidity (Jackson Turbidity Units)	88	37	27	27
Chemical Oxygen Demand*	--	--	--	--
Alkalinity as $CaCO_3$*	84	144	158	168
Calcium Hardness*	37	63	67	73
Magnesium Hardness*	8	14	13	14
Total Hardness*	124	216	224	240
Nitrate Nitrogen*	0.4	0.6	0.5	0.3
Ammonia Nitrogen*	0.1	<0.1	<0.1	<0.1
Total Organic Nitrogen*	--	--	--	--
Total Phosphorus*	0.42	0.45	0.10	0.10
Ortho Phosphorus*	0.12	<0.02	<0.02	<0.02
Calcium*	--	--	--	--
Magnesium*	--	--	--	--
Sodium*	3.7	6.6	2.0	6.7
Potassium*	--	--	--	--
Iron*	0.3	0.2	0.2	0.3
Manganese*	<1.0	<1.0	<1.0	<1.0
Sulfate*	40	93	180	64
Chloride*	--	--	--	--
Fluoride*	--	--	--	--
Silicone Dioxide*	--	--	--	--
Non-filterable solids*	305	85	50	65
Organic Carbon*	--	--	--	--
Secchi Disc (cm)	--	--	--	--

* expressed as mg/l

Appendix Table A-5. Continued.

Parameter	Og-17	Og-49	Og-80	Ogd-7
Source	Kersh(1977)	Kersh(1977)	Kersh(1977)	Kersh(1977)
Date	5-27-75	8-29-73	8-24-73	8-30-73
Water Temperature (^{o}C)	24.0	28.5	25.5	24.5
Discharge (cfs)	--	--	--	--
Dissolved oxygen*	6.2	4.6	3.7	4.5
Percent oxygen saturation (%)	72	58	43	53
pH	8.0	7.2	7.7	7.1
Colour (Platinum Cobalt Units)	--	--	--	--
Specific Conductance (µmhos/cm@ 25^{o}C)	520	480	400	1,400
Fecal Coliform (colonies/100 ml)	--	90	10	110
Streptococci (colonies/100 ml)	--	260	90	100
Turbidity (Jackson Turbidity Units)	22	23	23	25
Chemical Oxygen Demand*	--	25	13	32
Alkalinity as $CaCO_3$*	176	156	174	184
Calcium Hardness*	80	--	--	--
Magnesium Hardness*	16	--	--	--
Total Hardness*	266	--	--	--
Nitrate Nitrogen*	0.1	<0.1	<0.1	0.4
Ammonia Nitrogen*	<0.1	0.1	0.2	0.5
Total Organic Nitrogen*	--	--	--	--
Total Phosphorus*	0.12	0.23	0.18	0.22
Ortho Phosphorus*	<0.02	0.04	0.06	0.08
Calcium*	--	--	--	--
Magnesium*	--	--	--	--
Sodium*	7.4	6.7	17.5	140
Potassium*	--	16.0	6.3	9.6
Iron*	0.1	0.4	1.0	0.3
Manganese*	<1.0	<1.0	<1.0	1.4
Sulfate*	72	170	25	270
Chloride*	--	89	0.8	68
Fluoride*	--	0.32	0.72	0.37
Silicone Dioxide*	--	--	--	--
Non-filterable solids*	40	--	--	--
Organic Carbon*	--	--	--	--
Secchi Disc (cm)	--	--	--	30

* expressed as mg/l

Appendix Table A-5. Continued.

Parameter	Ogt-18	Ogtm-3		Ogts-2
Source	Kersh(1977)	Kersh(1977)	Kersh(1977)	Kersh(1977)
Date	8-20-73	8-20-73	6-11-74	8-20-73
Water Temperature (^{o}C)	28.5	28.0	20.0	26.0
Discharge (cfs)	--	--	--	--
Dissolved oxygen*	8.1	7.4	7.3	7.5
Percent oxygen saturation (%)	103	98	78	90
pH	7.4	5.9	7.0	6.9
Colour (Platinum Cobalt Units)	--	--	--	--
Specific Conductance (μmhos/cm@ 25^{o}C)	900	2,800	1,100	750
Fecal Coliform (colonies/100 ml)	<10	730	--	300
Streptococci (colonies/100 ml)	20	320	--	2,000
Turbidity (Jackson Turbidity Units)	9	8	35	10
Chemical Oxygen Demand*	10	8	--	10
Alkalinity as $CaCO_3$*	165	50	50	176
Calcium Hardness*	--	--	--	--
Magnesium Hardness*	--	--	--	--
Total Hardness*	--	--	528	--
Nitrate Nitrogen*	<0.1	<0.1	--	0.2
Ammonia Nitrogen*	0.2	1.0	--	0.2
Total Organic Nitrogen*	--	--	--	--
Total Phosphorus*	0.13	0.09	--	0.09
Ortho Phosphorus*	0.05	0.02	--	0.03
Calcium*	--	--	--	--
Magnesium*	--	--	--	--
Sodium*	--	41	--	27
Potassium*	--	9.0	--	5.4
Iron*	2.0	2.0	--	3.0
Manganese*	<1.0	4.9	--	<1.0
Sulfate*	410	1,800	--	1,950
Chloride*	0.7	1.0	--	0.7
Fluoride*	0.66	0.62	--	0.55
Silicone Dioxide*	7.1	7.3	--	6.8
Non-filterable solids*	--	--	--	--
Organic Carbon*	--	--	--	--
Secchi Disc (cm)	51	78	--	60

* expressed as mg/l

Appendix Table A-6. Chemical parameters analyzed at selected invertebrate sampling sites on the Sac and Pomme de Terre rivers, 1973.

Parameter	Os-4	Op-13
Source	Kersh (1977)	Kersh (1977)
Date	8-21-73	8-20-73
Water Temperature (°C)	26.0	29.0
Discharge (cfs)	--	--
Dissolved oxygen*	6.5	7.6
Percent saturation	79	98
pH	--	7.2
Colour (Platinum Cobalt Units)	--	--
Specific Conductance (µmhos/cm@ 25°C)	280	255
Fecal Coliform (colonies/100 ml)	250	30
Streptococci (colonies/100 ml)	550	70
Turbidity (Jackson Turbidity Units)	--	6
Chemical Oxygen Demand*	0	0
Alkalinity as $CaCO_3$*	--	134
Calcium Hardness*	--	--
Magnesium Hardness*	--	--
Total Hardness*	--	--
Nitrate Nitrogen*	0.5	1.0
Ammonia Nitrogen*	0.3	0.3
Total Organic Nitrogen*	--	--
Total Phosphorus*	0.16	0.07
Ortho Phosphorus*	0.05	0.02
Calcium*	--	--
Magnesium*	--	--
Sodium*	6.3	41.0
Potassium*	3.3	3.6
Iron*	<0.1	<0.1
Manganese*	<1.0	<1.0
Sulfate*	30	10
Chloride*	0.5	0.4
Fluoride*	0.26	0.19
Silicone Dioxide*	5.9	--
Non-filterable solids*	--	--
Organic Carbon*	--	--
Secchi Disc (cm)	--	--

* expressed as mg/l

Appendix Table A-7. Benthic invertebrate community characteristics for samples collected from the mainstem Osage River. 1975-76.

Sample Site	Density per square foot Su	Fa	Wi	Sp	Average	Number of taxa Su	Fa	Wi	Sp	Annual
0-4	107	79	2	*	49	27	29	11	*	41
0-33	228	120	32	*	152	45	42	27	*	63
0-67	6	2	68	12	22	10	8	28	15	38
0-78	2	410	133	291	186	11	15	17	15	30
0-183	74	82	*	85	82	16	26	*	23	39
0-208	44	116	243	68	115	26	30	33	25	49
0-238	90	181	89	45	100	21	18	25	17	38
0-271	138	69	117	234	113	32	27	32	32	55

Sample Site	Number of mayfly & stonefly taxa Su	Fa	Wi	Sp	Average	Margalef's species diversity index Su	Fa	Wi	Sp	Annual
0-4	4	6	3	*	9	3.6	4.3	2.6	*	5.3
0-33	9	8	8	*	14	5.1	5.6	4.4	*	7.0
0-67	2	1	8	4	10	1.9	1.9	4.3	2.5	5.4
0-78	0	1	2	1	3	2.9	1.7	2.2	1.8	3.2
0-183	4	6	*	8	9	2.6	3.6	*	3.4	5.0
0-208	8	9	11	10	17	3.8	3.9	3.9	3.5	5.5
0-238	5	3	7	3	8	3.0	2.3	3.4	2.7	4.5
0-271	7	9	8	8	12	4.2	3.8	4.3	4.5	6.4

* - No sample

Appendix Table A-8. Coefficient of similarity matrix for invertebrate sampling sites on the mainstem Osage River. 1975-76.

	0-4	0-33	0-67	0-78	0-183	0-208	0-238	0-271
0-4	--							
0-33	31	--						
0-67	19	13	--					
0-78	31	17	7	--				
0-183	49	54	11	19	--			
0-208	40	58	12	20	45	--		
0-238	49	58	10	22	74	43	--	
0-271	51	55	12	25	77	49	66	--

Appendix Table A-9. Benthic invertebrate community characteristics for samples collected from minor mainstem tributaries of the Osage River. 1975-76.

Sample Site	Density per square foot					Number of taxa				
	Su	Fa	Wi	Sp	Average	Su	Fa	Wi	Sp	Annual
Oma-11	231	116	331	304	250	40	37	43	54	81
Oma-23	151	16	16	75	64	29	23	18	33	55
Oma-29	60	73	309	217	165	27	36	52	46	66
Oma-46	39	92	450	361	209	26	21	23	28	52
Omal-3	17	13	55	39	31	24	20	33	23	46
Otv-6	78	5	43	37	42	31	15	33	25	58
Otv-30	50	44	43	70	51	27	31	23	29	57
Ogv-12	136	34	117	77	91	36	19	34	35	55
Ogv-17	105	48	117	79	87	36	25	32	36	58
Oaw-5	94	134	907	309	361	29	31	43	39	64
Oaw-10	260	177	410	46	220	34	41	45	27	67
Oawm-1	208	34	501	81	206	27	13	19	13	35
Oad-1	76	51	260	71	119	22	26	38	33	58
Ot-5	173	61	470	150	213	25	25	45	38	65
Od-6	16	69	122	326	133	24	32	41	54	65
Obb-5	89	45	243	149	133	24	18	35	38	54
Occ-11	44	32	157	557	224	20	20	37	40	55
Oc-10	77	445	274	98	235	21	26	29	21	54
Ow-11	256	389	190	1,091	468	30	43	45	55	76
Omg-7	36	203	533	119	202	17	22	27	23	45

Appendix Table A-9. Continued.

Sample Site	Number of mayfly & stonefly taxa					Margalef's species diversity index				
	Su	Fa	Wi	Sp	Average	Su	Fa	Wi	Sp	Annual
Oma-11	10	12	16	21	27	4.9	5.3	5.3	6.5	8.7
Oma-23	12	9	8	19	26	3.7	3.3	3.3	4.7	6.7
Oma-29	9	11	19	20	26	4.2	5.5	6.5	6.0	7.6
Oma-46	5	5	6	8	12	4.4	3.0	2.7	3.4	5.7
Omal-3	10	10	15	13	21	4.5	3.9	5.1	3.8	6.4
Otv-6	13	8	16	13	27	4.4	3.6	5.1	3.9	7.5
Otv-30	10	15	14	16	28	4.3	4.9	3.8	4.4	8.2
Ogv-12	10	7	15	14	21	4.7	3.0	4.6	5.0	6.4
Ogv-17	9	11	14	14	20	5.2	3.9	4.3	5.1	6.9
Oaw-5	10	11	14	13	22	4.2	4.3	4.7	4.9	6.7
Oaw-10	13	14	12	12	23	4.3	5.2	5.2	4.1	7.2
Oawm-1	4	3	3	1	5	3.5	2.1	2.2	1.9	3.9
Oad-1	8	9	16	17	29	3.3	4.0	4.7	5.1	6.8
Ot-5	8	11	17	17	24	3.3	3.9	5.3	5.2	7.3
Od-6	8	10	13	19	22	4.8	4.9	5.8	6.7	7.7
Obb-5	9	6	15	14	20	3.5	2.9	4.5	4.9	6.3
Occ-11	7	8	12	14	17	3.1	3.4	4.9	4.4	5.9
Oc-10	4	4	9	8	16	2.9	2.9	3.5	3.0	5.6
Ow-11	6	15	12	15	24	3.7	5.2	6.0	6.0	7.8
Omg-7	5	5	5	4	9	2.8	2.8	3.2	3.2	5.1

Appendix Table A-10. Coefficient of similarity matrix for invertebrate sampling sites on minor mainstem tributaries of the Osage River. 1975-76.

	Oma-11	Oma-23	Oma-29	Oma-46	Omal-3	Otv-6	Otv-30	Ogv-12	Ogv-17	Oaw-5	Oaw-10	Oawm-1	Oad-1	Od-6	Ot-5	Obb-5	Occ-11	Oc-10	Ow-11	Omg-7
Oma-11	--																			
Oma-23	34	--																		
Oma-29	60	49	--																	
Oma-46	56	28	32	--																
Omal-3	14	45	19	12	--															
Otv-6	18	46	24	12	50	--														
Otv-30	25	63	36	21	48	56	--													
Ogv-12	47	63	62	37	24	27	47	--												
Ogv-17	40	67	59	33	29	30	50	74	--											
Oaw-5	47	24	45	33	8	12	17	31	28	--										
Oaw-10	71	34	65	49	12	17	27	54	46	50	--									
Oawm-1	43	29	45	49	10	14	19	36	39	66	52	--								
Oad-1	49	55	62	38	30	29	44	74	65	33	54	42	--							
Od-6	48	53	47	43	23	27	38	51	55	33	47	44	47	--						
Ot-5	66	39	59	50	17	19	29	54	48	37	71	49	56	52	--					
Obb-5	54	49	44	55	22	24	37	61	61	24	54	33	58	48	62	--				
Occ-11	55	35	36	73	17	15	25	41	36	20	45	34	42	40	58	57	--			
Oc-10	46	24	27	68	9	10	14	31	27	15	35	26	31	30	42	47	36	--		
Ow-11	47	18	28	49	9	8	13	23	22	33	39	43	28	31	43	36	54	38	--	
Omg-7	38	28	42	36	10	11	17	35	34	30	42	49	41	33	49	35	10	8	11	--

Appendix Table A-11. Benthic invertebrate community characteristics for samples collected from the Marais des Cygnes River Basin. 1975-76.

Sample Site	Density per square foot					Number of taxa				
	Su	Fa	Wi	Sp	Average	Su	Fa	Wi	Sp	Annual
Omdc-9	386	*	84	*	235	32	*	30	*	43
Omdc-24	324	300	728	67	354	29	41	28	33	63
Omdcm-4	14	623	400	83	295	18	27	17	18	37
Omdcm-12	345	*	167	721	402	20	*	21	21	32
Omdcml-1	22	149	467	927	390	20	28	13	21	43

Sample Site	Number of mayfly & stonefly taxa					Margalef's species diversity index				
	Su	Fa	Wi	Sp	Annual	Su	Fa	Wi	Sp	Annual
Omdc-9	10	*	8	*	12	3.9	*	4.5	*	5.1
Omdc-24	10	10	13	10	19	3.6	4.7	2.9	4.7	6.3
Omdcm-4	5	7	2	5	8	3.5	3.0	1.9	2.5	3.8
Omdcm-12	4	*	4	5	8	2.3	*	2.8	2.3	3.3
Omdcml-1	7	6	2	6	10	3.7	3.8	1.5	2.2	4.5

* - No sample

Appendix Table A-12. Coefficient of similarity matrix for invertebrate sampling site on the Marais des Cygnes River Basin. 1975-76.

	Omdc-9	Omdc-24	Omdcm-4	Omdcm-12	Omdcml-1
Omdc-9	--				
Omdc-24	43	--			
Omdcm-4	42	53	--		
Omdcm-12	27	68	52	--	
Omdcml-1	21	45	24	58	--

Appendix Table A-13. Benthic invertebrate community characteristics for samples collected from the Little Osage and Marmaton rivers. 1975-76.

Sample Site	Density per square foot Su	Fa	Wi	Sp	Average	Number of taxa Su	Fa	Wi	Sp	Annual
Olo-4	28	54	17	8	27	18	18	8	9	26
Olo-5	20	199	51	55	78	16	20	15	22	32
Om-9	40	186	235	102	141	15	25	21	20	32
Om-24	23	421	187	45	169	14	31	22	18	43
Omw-6	7	176	159	47	87	10	14	17	21	28
Omlw-9	26	29	67	23	36	12	18	12	11	27

Sample Site	Number of mayfly & stonefly taxa Su	Fa	Wi	Sp	Annual	Margalef's species diversity index Su	Fa	Wi	Sp	Annual
Olo-4	5	5	3	4	8	3.1	2.8	1.4	2.0	3.7
Olo-5	7	7	2	7	9	3.0	2.6	2.3	3.2	3.9
Om-9	5	6	7	5	9	2.3	3.1	2.5	2.7	3.5
Om-24	6	9	7	6	13	2.5	3.7	2.9	2.9	4.9
Omw-6	1	2	5	4	5	2.0	1.8	2.2	3.4	3.4
Omlw-9	2	3	2	3	5	2.1	3.1	1.8	1.9	3.7

Appendix Table A-14. Coefficient of similarity matrix for invertebrate sampling sites on the Little Osage and Marmaton rivers. 1975-76.

	Olo-4	Olo-5	Om-9	Om-24	Omw-6	Omlw-9
Olo-4	--					
Olo-5	47	--				
Om-9	32	60	--			
Om-24	24	52	70	--		
Omw-6	36	63	78	62	--	
Omlw-9	41	30	28	22	35	--

Appendix Table A-15. Benthic invertebrate community characteristics for samples collected from the South Grand River and its tributaries. 1975-76.

Sample Site	Density per square foot					Number of taxa				
	Su	Fa	Wi	Sp	Average	Su	Fa	Wi	Sp	Annual
Og-17	53	497	1,085	431	516	15	28	29	25	39
Og-49	39	188	19	77	81	20	19	11	20	30
Og-80	206	160	220	79	166	21	20	26	25	45
Og-100	227	121	96	208	177	28	24	23	32	47
Oge-7	281	338	648	310	394	35	34	18	26	58
Ogd-7	144	273	124	79	155	16	20	22	19	36
Ogds-1	115	653	167	763	424	13	28	14	21	35
Ogdb-5	85	768	145	358	339	17	27	22	20	37
Ogt-18	3	59	29	54	36	7	27	16	19	35
Ogts-2	6	6	18	31	15	10	9	12	12	23
Ogte-5	67	164	460	346	259	17	26	23	19	33
Ogtm-3	41	382	155	120	175	13	21	14	14	28
Ogtw-3	59	121	190	727	274	16	18	26	34	44
Ogb-5	113	198	250	250	169	14	17	14	17	27

Appendix Table A-15. Continued.

Sample Site	Number of mayfly & stonefly taxa					Margalef's species diversity index				
	Su	Fa	Wi	Sp	Annual	Su	Fa	Wi	Sp	Annual
Og-17	4	7	7	6	10	2.2	3.1	3.0	2.8	3.8
Og-49	7	6	3	8	11	3.1	2.3	1.8	2.8	3.5
Og-80	7	7	7	10	12	2.6	2.5	3.2	3.5	4.9
Og-100	3	4	4	7	8	3.4	3.2	3.1	4.0	5.1
Oge-7	4	5	3	3	8	4.2	4.0	1.9	3.0	5.8
Ogd-7	6	6	6	4	9	2.1	2.5	3.0	2.8	4.1
Ogds-1	5	8	2	9	13	1.8	3.2	1.8	2.3	3.6
Ogdb-5	4	5	5	4	7	2.5	3.0	3.0	2.4	3.9
Ogt-18	1	7	4	3	7	1.7	4.0	2.6	2.8	4.6
Ogts-2	3	3	2	2	5	2.1	1.9	2.0	1.9	3.3
Ogte-5	6	5	6	6	10	2.6	3.5	2.7	2.3	3.6
Ogtm-3	3	6	3	4	9	2.1	2.5	1.8	1.9	3.1
Ogtw-3	5	8	6	9	13	2.4	2.5	3.4	3.8	4.7
Ogb-5	4	3	2	2	4	1.8	2.1	1.9	2.3	3.0

Appendix Table A-16. Coefficient of similarity matrix for invertebrate sampling sites on the South Grand River and its tributaries. 1975-76.

	Og-17	Og-49	Og-80	Og-100	Oge-7	Ogd-7	Ogds-1	Ogdb-5	Ogt-18	Ogts-2	Ogte-5	Ogtm-3	Ogtw-3	Ogb-5
Og-17	--													
Og-49	29	--												
Og-80	49	60	--											
Og-100	15	15	23	--										
Oge-7	13	13	18	58	--									
Ogd-7	46	36	56	33	26	--								
Ogds-1	39	26	48	24	20	50	--							
Ogdb-5	28	26	44	31	21	41	56	--						
Ogt-18	13	39	31	29	18	34	15	18	--					
Ogts-2	6	30	17	15	9	18	7	9	58	--				
Ogte-5	34	30	57	57	49	50	51	59	23	11	--			
Ogtm-3	47	52	65	18	15	67	46	31	27	14	42	--		
Ogtw-3	23	30	31	51	76	35	28	30	23	10	59	35	--	
Ogb-5	15	14	22	65	39	31	22	29	28	15	46	18	38	--

Appendix Table A-17. Benthic invertebrate community characteristics for samples collected from the Sac River and its tributaries. 1975-76.

Sample Site	Density per square foot					Number of taxa				
	Su	Fa	Wi	Sp	Average	Su	Fa	Wi	Sp	Annual
Os-4	154	137	176	213	168	25	23	30	31	50
Os-35	103	74	428	74	168	37	35	37	29	62
Os-49	11	13	14	17	14	15	12	14	14	25
Os-82	46	16	101	254	97	28	26	43	40	66
Os-86	47	86	244	360	188	28	28	57	44	69
Osls-79	109	93	260	502	232	29	30	41	41	62
Osls-98	138	116	199	699	282	26	27	28	19	41
Osls-103	363	136	375	277	293	21	16	13	9	33
Osb-8	94	173	407	295	242	41	42	52	51	77
Osb-21	226	14	177	234	163	31	16	30	35	57
Osbh-3	87	37	331	296	188	31	23	49	48	70
Oscl-1	158	93	312	393	239	31	33	44	46	65
Ost-6	42	24	251	151	115	26	24	49	40	61
Ostl-3	66	90	281	173	152	28	29	53	50	70
Oss-11	71	31	242	518	217	24	15	33	30	46
Oss-18	118	1,027	984	54	734	27	34	35	20	48
Osc-1	54	33	19	68	37	19	19	18	28	41
Osc-20	69	121	118	114	94	34	36	34	26	60
Osch-14	114	46	98	122	95	26	20	26	30	51
Osch-131	174	46	401	2,650	793	24	14	23	18	39

Appendix Table A-17. Continued.

Sample Site	Number of mayfly & stonefly taxa					Margalef's species diversity index				
	Su	Fa	Wi	Sp	Annual	Su	Fa	Wi	Sp	Annual
Os-4	5	5	11	10	15	3.2	3.1	4.0	4.0	5.6
Os-35	8	10	14	10	18	5.1	5.0	4.2	4.1	6.7
Os-49	5	3	4	3	5	2.9	2.2	2.5	2.4	3.8
Os-82	10	10	17	17	27	4.3	4.8	6.1	5.0	7.8
Os-86	8	11	23	18	27	4.6	4.1	7.2	5.4	7.8
Osls-79	10	12	18	18	26	4.1	4.2	5.2	4.8	6.8
Osls-98	9	10	10	6	15	3.6	3.8	3.6	2.1	4.5
Osls-103	8	3	4	1	9	2.5	2.1	1.5	1.0	3.5
Osb-8	13	13	16	15	27	6.0	5.7	6.3	6.4	8.5
Osb-21	10	3	6	12	19	4.0	3.2	3.9	4.5	6.5
Osbh-3	8	14	16	20	27	4.6	5.4	6.1	6.1	7.9
Oscl-1	12	15	19	18	26	4.2	4.8	5.4	5.6	7.1
Ost-6	10	12	21	17	24	4.1	4.2	6.1	5.5	7.2
Ostl-3	9	10	19	20	27	4.3	4.3	6.7	6.8	8.1
Oss-11	7	4	10	8	15	3.6	2.5	4.1	3.5	5.1
Oss-18	7	5	7	7	9	3.8	3.6	3.8	3.1	4.8
Osc-1	8	10	7	7	19	2.9	3.1	3.1	4.1	5.5
Osc-20	11	13	14	5	22	5.2	4.9	4.8	3.7	7.3
Osch-14	5	7	9	9	16	3.7	3.2	3.6	4.1	6.1
Osch-131	4	1	4	3	7	3.2	2.2	2.7	1.7	3.7

Appendix Table A-18. Coefficient of similarity matrix for invertebrate sampling sites on the Sac River and its tributaries. 1975-76.

	Os-4	Os-35	Os-49	Os-82	Os-86	Osls-79	Osls-98	Osls-103	Osb-8	Osb-21	Osbh-3	Oscl-1	Ost-6	Ostl-3	Oss-11	Oss-18	Osc-1	Osc-20	Osch-14	Osch-131
Os-4	--																			
Os-35	25	--																		
Os-49	15	13	--																	
Os-82	29	37	19	--																
Os-86	35	36	14	61	--															
Osls-79	33	53	10	41	57	--														
Osls-98	43	21	8	18	30	34	--													
Osls-103	53	14	6	15	25	24	36	--												
Osb-8	53	55	11	36	50	54	50	35	--											
Osb-21	40	46	15	37	51	52	52	31	60	--										
Osbh-3	44	41	15	34	46	45	41	28	53	47	--									
Oscl-1	54	32	10	49	60	60	45	38	66	46	44	--								
Ost-6	46	35	20	54	58	47	34	29	48	45	51	56	--							
Ostl-3	30	37	17	56	68	43	27	18	48	41	52	51	43	--						
Oss-11	62	31	11	34	39	49	55	44	63	65	41	65	45	35	--					
Oss-18	32	12	4	11	18	20	32	60	29	27	25	29	17	16	34	--				
Osc-1	16	32	28	38	22	26	13	6	25	31	17	20	26	27	24	7	--			
Osc-20	28	28	23	34	33	33	21	11	39	38	40	31	26	38	34	13	38	--		
Osch-14	32	41	23	38	33	36	41	19	45	71	39	37	41	42	49	17	35	35	--	
Osch-131	14	9	3	9	13	13	28	29	18	22	15	17	14	10	22	38	4	8	15	--

Appendix Table A-19. Benthic invertebrate community characteristics for samples collected from the Pomme de Terre River and Lindley Creek. 1975-76.

Sample Site	Density per square foot					Number of taxa				
	Su	Fa	Wi	Sp	Average	Su	Fa	Wi	Sp	Annual
Op-13	30	105	17	122	67	30	33	11	42	62
Op-27	61	50	105	117	81	29	27	32	31	54
Op-55	207	18	156	133	125	28	22	41	33	59
Op-83	141	79	171	147	137	36	30	45	44	71
Opl-46	521	85	165	300	261	29	23	35	38	57
Opl-63	209	53	128	358	183	25	25	36	37	57

Sample Site	Number of mayfly & stonefly taxa					Margalef's species diversity index				
	Su	Fa	Wi	Sp	Annual	Su	Fa	Wi	Sp	Annual
Op-13	11	10	7	14	23	4.8	4.5	1.9	5.6	7.5
Op-27	6	7	8	8	11	4.2	4.0	4.3	4.1	6.4
Op-55	11	11	14	17	26	3.6	4.0	5.4	4.5	6.9
Op-83	9	11	16	19	28	5.0	5.0	5.9	5.9	8.2
Opl-46	9	9	15	17	26	3.4	3.4	4.6	4.8	6.2
Opl-63	7	10	11	14	20	3.2	4.0	4.9	4.5	6.4

Appendix Table A-20. Coefficient of similarity matrix for invertebrate sampling sites on the Pomme de Terre River and Lindley Creek. 1975-76.

Op-13	--					
Op-27	52	--				
Op-55	61	63	--			
Op-83	47	64	69	--		
Opl-46	29	24	43	39	--	
Opl-63	36	38	54	49	66	--
	Op-13	Op-27	Op-55	Op-83	Opl-46	Opl-63

Appendix Table A-21. Benthic invertebrate community characteristics for samples collected from the Niangua, Bennett Spring, and Little Niangua rivers. 1975-76.

Sample Site	Density per square foot					Number of taxa				
	Su	Fa	Wi	Sp	Average	Su	Fa	Wi	Sp	Annual
On-33	103	145	226	198	165	40	35	39	46	66
OBS-0	307	243	253	181	246	19	17	20	16	33
On-85	148	133	303	202	198	34	37	54	45	74
On-105	68	42	119	150	98	24	27	40	39	57
Oln-17	33	39	30	94	49	32	38	23	36	65
Oln-132	155	266	75	27	72	33	25	17	28	57

Sample Site	Number of mayfly & stonefly taxa					Margalef's species diversity index				
	Su	Fa	Wi	Sp	Annual	Su	Fa	Wi	Sp	Annual
On-33	15	12	17	17	26	5.5	4.6	4.8	5.8	7.2
OBS-0	4	3	6	5	13	2.3	2.1	2.5	2.1	3.6
On-85	11	12	21	21	28	4.7	5.0	6.6	5.8	8.2
On-105	8	8	15	17	21	3.7	4.5	5.5	5.2	6.9
Oln-17	12	15	10	21	28	5.2	5.9	3.7	5.0	8.2
Oln-132	11	14	9	17	25	4.5	4.5	2.4	5.0	7.1

Appendix Table A-22. Coefficient of similarity matrix for invertebrate sampling sites on the Niangua, Bennett Spring, and Little Niangua rivers. 1975-76.

On-33	--					
OBS-0	28	--				
On-85	37	47	--			
On-105	41	34	46	--		
Oln-17	29	48	59	45	--	
Oln-132	28	22	26	13	24	--
	On-33	OBS-0	On-85	On-105	Oln-17	Oln-132

Appendix Table A-23. Summary of similar benthic macroinvertebrate communities in the Osage River basin listed by sampling site.

River and Sample Site	Similar benthos communities (C≥50) listed in descending order of similarity
Osage River	
O-271	O-183, O-238, Ost-6, Omdc-9, Osbh-3, Og-100, Ogv-12, Os-4, Ogb-5, O-33, Ot-5, Obb-5, Osb-8, Op-27, Od-6, Om-9, and Osb-21.
O-238	Os-4, O-183, O-271, Og-100, Obb-5, Ogb-5, O-33, Ost-6, Oss-11, Oma-46, Ot-5, Occ-11, Omdc-9, Osb-8, Oscl-1, and Oc-10.
O-208	Oma-29, Op-27, Om-9, Op-55, Os-35, Omw-6, Ogv-12, Oad-1, Ogv-17, Osls-79, Oma-11, Op-83, O-33, Oaw-10, Ot-5, Og-80, Op-13, On-85, Osb-21, Osbh-3, Osch-14, and Od-6.
O-183	O-271, O-238, Ost-6, Og-100, Os-4, Ogb-5, Ogv-12, O-33, Obb-5, and Omdc-9.
O-78	Ogb-5
O-67	
O-33	Oaw-10, Ot-5, Om-9, Oma-29, Omw-6, Op-27, Osb-8, Oad-1, Obb-5, O-208, O-238, Ogv-12, O-271, Oma-11, Ogv-17, O-183, Og-80, Op-83, Omdc-9, Ost-6, Ogd-7, and Os-35.
O-4	Ogt-18, Omlw-9, and O-271.
Maries River	
Oma-46	Ogte-5, Occ-11, Oss-11, Oc-10, Os-4, Ogtw-3, Osls-98, Og-100, Osls-103, Oge-7, Obb-5, Osb-21, O-238, Oscl-1, Og-80, Omdc-9, Omdcm-4, Osb-8, and Ot-5.
Oma-29	O-208, Oaw-10, Os-35, Oad-1, Ogv-12, O-33, Om-9, Osls-79, Ot-5, Ogv-17, Op-55, Omw-6, Op-27, Op-83, Og-80, On-85, Osb-21, and Osbh-3.
Oma-23	Oln-132, Ogv-17, Otv-30, Ogv-12, Op-27, Oad-1, On-105, Op-55, Op-83, Od-6, Os-82, and Ogt-18.
Omal-3	Oln-132 and Otv-6.

Appendix Table A-23. Continued.

River and Sample Site	Similar benthos communities (C≥50) listed in descending order of similarity
Oma-11	Oaw-10, Ot-5, Osb-8, Oss-11, Oscl-1, Oma-29, O-208, Op-55, Oma-46, Ogte-5, Omdc-9, Os-35, Osls-79, Occ-11, Om-9, Obb-5, Os-4, O-33, Op-83, Osb-21, On-85, Og-80, and Ogtw-3.
Tavern Creek	
Otv-30	Oln-132, Oma-23, Oln-17, Otv-6, On-105, and Ogv-17.
Otv-6	Otv-30, Olo-4, and Omal-3.
Gravois Creek	
Ogv-17	Ogv-12, Oma-23, Oln-132, Oad-1, Op-27, Obb-5, O-208, Oma-29, Ost-6, Op-83, Omw-6, Od-6, Om-9, O-33, Op-55, and Otv-30.
Ogv-12	Ogv-17, Oad-1, Op-27, Oma-23, Oma-29, O-208, Oln-132, Obb-5, Op-83, O-271, Ost-6, O-33, Oaw-10, Ot-5, O-183, Osbh-3, Od-6, and Op-55.
Auglaize Creek	
Oaw-10	Oma-11, Ot-5, Oma-29, O-33, Osb-8, Os-35, O-208, Om-9, Osb-21, Osls-79, Og-80, Obb-5, Ogv-12, Om-24, Oad-1, Oscl-1, Oawm-1, Ogte-5, Omdc-9, Osls-98, and Oaw-5.
Oawm-1	Og-80, Omdc-24, Ogte-5, Oaw-5, Ogdb-5, Om-9,Ogds-1, Omdcm-12, Osls-98, Osb-21, Ogd-7, Om-24, Omw-6, Ogtm-3, Omdcml-1, Oaw-10, and Osch-14.
Oaw-5	Oawm-1, Omdcm-12, Ogds-1, Og-80, Omdcml-1, Omdc-24, Ogdb-5, and Oaw-10.
Oad-1	Ogv-12, Ogv-17, Oma-29, Op-55, Op-83, O-208, Oln-132, Op-27, Obb-5, O-33, Ot-5, Omw-6, Ost-6, Om-9, Oaw-10, and Osbh-3.
Deer Creek	
Od-6	Ostl-3, Osch-14, Om-9, Os-86, Ost-6, Oln-132, Op-27, Ogv-17, Osb-21, Oma-23, Op-83, Ot-5, O-271, On-105, Op-55, Ogv-12, O-208, Osbh-3, and Og-80.

Appendix Table A-23. Continued.

River and Sample Site	Similar benthos communities ($C \geq 50$) listed in descending order of similarity
Turkey Creek	
Ot-5	Oaw-10, Osb-8, Oma-11, Obb-5, O-33, Osbh-3, Oscl-1, Oma-29, Osls-79, Occ-11, Op-55, Oad-1, O-208, Osb-21, Oss-11, Opl-63, Ogv-12, O-238, Om-9, Omdc-9, Ogte-5, O-271, Od-6, Ogd-7, Ostl-3, Oma-46, On-85, and Os-4.
Big Buffalo Creek	
Obb-5	O-238, Ot-5, Ogv-12, Ogv-17, Oss-11, Omdc-9, Oad-1, O-33, Ost-6, Occ-11, Oscl-1, Oma-46, Oma-11, Oaw-10, Os-4, Osb-8, O-271, O-183, Oln-132, and Og-100.
Cole Camp Creek	
Occ-11	Oma-46, Oc-10, Os-4, Ogtw-3, Ogte-5, Oss-11, Og-100, Osls-103, Ot-5, Oge-7, Obb-5, Oma-11, Oscl-1, O-238, Osb-8, and Osbh-3.
Clear Creek	
Oc-10	Osls-103, Ogb-5, Occ-11, Oma-46, Os-4, Og-100, Ogte-5, Ogtw-3, Oge-7, Omg-7, Oss-11, and O-238.
Weaubleau Creek	
Ow-11	Opl-46, Osb-8, Oss-11, Ogte-5, and Opl-63.
Monegaw Creek	
Omg-7	Ogd-7, Ogb-5, Oc-10, Osb-8, Ogte-5, Omw-6, Osbh-3, and Osb-21.
Marais des Cygnes River	
Omdc-24	Oawm-1, Omdcm-12, Ogds-1, Og-80, Og-17, Ogd-7, Om-24, Ogte-5, Oaw-5, Omdcm-4, Ogdb-5, Ogtm-3, Om-9, Osls-98, and Osb-8.
Omdc-9	Obb-5, O-271, Og-100, Oma-11, Oscl-1, Ot-5, Os-4, Osb-8, O-238, Oaw-10, O-33, Oss-11, Oma-46, O-183, and Ost-6.

Appendix Table A-23. Continued.

River and Sample Site	Similar benthos communities ($C \geq 50$) listed in descending order of similarity
Omdcm-12	Ogds-1, Omdc-24, Oawm-1, Oaw-5, Omdcml-1, Ogte-5, Ogdb-5, Omdcm-4, Og-80, Ogtm-3 and Ogd-7.
Omdcm-4	Ogd-7, Og-17, Ogte-5, Om-24, Omdc-24, Omdcm-12, Oma-46 and Osb-8.
Omdcml-1	Ogds-1, Osch-131, Omdcm-12, Oaw-5, Oawm-1 and Ogdb-5.
Marmaton River	
Om-24	Og-80, Ogtm-3, Om-9, Ogd-7, Os-35, Omw-6, Osb-21, Oawm-1, Omdc-24, Opl-46, Osch-14, Oaw-10, Opl-63, Og-49, Omdcm-4, Osb-8, Op-55 and Olo-5.
Om-9	Og-80, Omw-6, Om-24, O-208, Op-55, Os-35, Osb-21, O-33, Oawm-1, Og-49, Oma-29, Op-27, Ogtm-3, Olo-5, Ogd-7, Osch-14, Opl-63, Osb-8, On-85, Oaw-10, Od-6, Oma-11, Op-83, Ogv-17, Oad-1, Ot-5, Omdc-24, Op-13 and O-271.
Omw-6	Om-9, Om-24, Og-80, O-208, Olo-5, Ogd-7, Osb-21, Os-35, Opl-63, O-33, Oma-29, Op-55, Ogtm-3, Osch-14, Op-27, Ogv-17, Oad-1, Oawm-1, Osb-8, Og-49, Op-13, Op-83, Omg-7, Ost-6 and Oln-132.
Omlw-9	Ogts-2, Ogt-18, Os-49 and O-4.
Little Osage River	
Olo-5	Omw-6, Om-9, Og-80, Og-49, Opl-63, Om-24, Osc-1 and Os-35.
Olo-4	Osc-1, Op-13 and Otv-6.
South Grand River	
Og-100	Os-4, Ogb-5, Oc-10, O-238, Occ-11, Oma-46, O-183, O-271, Oge-7, Oss-11, Ogte-5, Omdc-9, Osls-103, Ogtw-3, Obb-5 and Oscl-1.
Og-80	Om-9, Oawm-1, Om-24, Omw-6, Ogtm-3, Osb-21, Os-35, Op-55, Og-49, Omdc-24, Osb-8, Osch-14, Oaw-5, Ogte-5, Olo-5, Ogd-7, O-208, Opl-63, Oaw-10, Oma-29, Op-83, On-85, O-33, Oss-11, Oma-11, Oma-46, Omdcm-12 and Od-6.

Appendix Table A-23. Continued.

River and Sample Site	Similar benthos communities (C≥50) listed in descending order of similarity
Og-49	Om-9, Og-80, Osch-14, Op-55, Op-13, Olo-5, Omw-6, Om-24, Osb-21, Osc-1,and Ogtm-3.
Og-17	Omdc-24 and Omdcm-4.
Oge-7	Ogtw-3, Osls-103, Oc-10, Os-4, Og-100, Occ-11 and Oma-46.
Ogb-5	Oc-10, Osls-103, Og-100, O-238, Omg-7, O-78, Os-4, O-271 and O-183.
Ogds-1	Omdcm-12, Omdcml-1, Omdc-24, Oawm-1, Oaw-5, Ogdb-5, Osch-131, Ogte-5 and Ogd-7.
Ogd-7	Ogtm-3, Om-24, Omg-7, Omw-6, Omdcm-4, Oawm-1, Om-9, Omdc-24, Os-35, Og-80, Osb-8, Opl-46, Osb-21, Ot-5, Ogds-1, Ogte-5, O-33, Omdcm-12 and Osch-14.
Ogdb-5	Oawm-1, Osls-98, Ogte-5, Omdcm-12, Ogds-1, Omdcml-1, Omdc-24 and Oaw-5.
Ogt-18	O-4, Omlw-9, Ogts-2, Op-27, O-183 and Oma-23.
Ogts-2	Os-49, Omlw-9 and Ogt-18.
Ogte-5	Oma-46, Occ-11, Oawm-1, Osls-98, Oc-10, Oss-11, Os-4, Ogdb-5, Ogtw-3, Og-80, Og-100, Omdcm-12, Osb-8, Oma-11, Osb-21, Omdcm-4, Ow-11, Omdc-24, Ot-5, Osls-103, Oaw-10, Omg-7, Ogds-1 and Ogd-7.
Ogtm-3	Om-24, Ogd-7, Opl-46, Og-80, Opl-63, Os-35, Om-9, Omw-6, Oawm-1, Osb-8, Og-49, Omdc-24, Osb-21, Omdcm-12 and Osch-14.
Ogtw-3	Oge-7, Osls-103, Occ-11, Oc-10, Oma-46, Os-4, Ogte-5, Oss-11, Oscl-1, Og-100, Osb-8, Oma-11 and Oss-18.
Sac River	
Os-86	Ostl-3, Os-82, Oscl-1, Ost-6, Osls-79, On-85, Op-83, Od-6, Osb-21 and Osb-8.
Os-82	Os-86, Op-83, Ostl-3, Op-55, Ost-6, Oma-23 and Oln-132.
Os-49	Ogts-2 and Omlw-9.

Appendix Table A-23. Continued.

River and Sample Site	Similar benthos communities (C≥50) listed in descending order of similarity
Os-35	O-208, Oma-29, Om-24, Om-9, Og-80, Ogtm-3, Omw-6, Op-55, Oaw-10, Ogd-7, Oma-11, Osb-8, Osls-79, Opl-46, O-33 and Olo-5.
Os-4	Og-100, Occ-11, O-238, Oma-46, Oc-10, Oss-11, Ogte-5, Ogtw-3, Oge-7, O-183, O-271, Ogb-5, Oma-11, Obb-5, Omdc-9, Oscl-1, Osls-103, Osb-8 and Ot-5.
Osls-103	Oc-10, Ogtw-3, Oge-7, Ogb-5, Occ-11, Oss-18, Oma-46, Ogte-5, Os-4 and Og-100.
Osls-98	Ogte-5, Oma-46, Ogdb-5, Oawm-1, Oss-11, Oaw-10, Omdc-24, Osb-21 and Osb-8.
Osls-79	Op-83, Op-55, Opl-63, Oma-29, Oscl-1, Ot-5, O-208, Oma-11, Oaw-10, On-85, Osb-8, Os-35 and Osb-21.
Oscl-1	Osb-8, Oss-11, Oma-11, Ot-5, Os-86, Osls-79, Op-83, Obb-5, Omdc-9, Ost-6, Ogtw-3, Occ-11, Os-4, Oaw-10, Oma-46, O-238, Ostl-3, Op-55 and Og-100.
Osb-21	Osch-14, Oss-11, Og-80, Om-9, Om-24, Omw-6, Oawm-1, Osb-8, Oaw-10, Ogte-5, Ot-5, Oma-46, Od-6, Opl-63, Ogd-7, Og-49, Oma-11, Op-55, Ogtm-3, O-208, Osls-79, Osls-98, Os-86, Oma-29, Omg-7 and O-271.
Osb-8	Ot-5, Oscl-1, Oma-11, Oss-11, Osb-21, Opl-63, O-33, Oaw-10, Og-80, Om-9, Ogte-5, Ogd-7, Op-83, Omw-6, Os-35, Opl-46, Obb-5, Omg-7, Omdc-9, Osls-79, Op-55, Ogtm-3, Occ-11, O-238, O-271, Om-24, Os-4, Osbh-3, Oma-46, On-85, Ogtw-3, Omdc-24, Omdcm-4, Os-86 and Osls-98.
Osbh-3	Ot-5, O-271, Op-27, Osb-8, Oad-1, Op-83, Omg-7, Ogv-12, O-208, Ostl-3, Od-6, Ost-6, Oma-29, and Occ-11.
Ost-6	O-271, O-183, Ogv-12, Obb-5, Ogv-17, Os-86, Op-83, Od-6, Oscl-1, Op-27, Oad-1, O-238, Os-82, Op-55, O-33, Osbh-3 and Omdc-9.
Ostl-3	Os-86, Od-6, Os-82, Op-27, Oln-132, Op-55, Osbh-3, On-85, On-105, Ot-5 and Oscl-1.
Oss-18	Osls-103 and Ogtw-3.

Appendix Table A-23. Continued.

River and Sample Site	Similar benthos communities (C≥50) listed in descending order of similarity
Oss-11	Oma-46, Osb-21, Oscl-1, Oma-11, Occ-11, Ogte-5, Osb-8, Os-4, Obb-5, Og-100, Ogtw-3, Ow-11, Ot-5, O-238, Osls-98, Og-80, Oc-10, and Omdc-9.
Osc-20	
Osc-1	Olo-4, Op-13, Og-49 and Olo-5.
Osch-131	Omdcml-1 and Ogds-1.
Osch-14	Osb-21, Og-49, Om-9, Og-80, Od-6, Omw-6, Om-24, Op-55, Oawm-1, O-208, Ogd-7 and Ogtm-3.
Pomme de Terre River	
Op-83	Op-55, Op-27, Osls-79, On-85, Oad-1, Ogv-12, O-208, Oscl-1, Ost-6, Oma-29, Oln-132, Ogv-17, Os-82, Os-86, Om-9, Osb-8, Oma-11, Oma-23, Og-80, Od-6, O-33, Omw-6 and Osbh-3.
Op-55	On-85, Op-83, O-208, Om-9, Op-27, Oad-1, Op-13, Osls-79, Og-80, Oma-29, Og-49, Omw-6, Os-35, Oma-11, Ot-5, Oln-132, Os-82, Opl-63, Oma-23, Ogv-17, Osb-8, Osch-14, Om-24, Osb-21, Ostl-3, Od-6, Ost-6, Ogv-12 and Oscl-1.
Op-27	O-208, Ogv-12, Ogv-17, Op-83, Op-55, Oln-132, Om-9, Oma-23, Oad-1, O-33, Oma-29, Omw-6, Od-6, Osbh-3, Ost-6, Ogt-18, Ostl-3, On-85, Op-13 and O-271.
Op-13	Osc-1, Op-55, Og-49, O-208, Omw-6, Op-27, Olo-4 and Om-9.
Opl-63	Opl-46, Ogtm-3, Osls-79, Omw-6, Osb-8, Om-9, Olo-5, Og-80, Ot-5, Osb-21, Op-55, Om-24 and Ow-11.
Opl-46	Opl-63, Ogtm-3, Ow-11, Om-24, Ogd-7, Osb-8 and Os-35.
Niangua River	
On-105	Oln-132, Oma-23, Otv-30, Od-6 and Ostl-3.
On-85	Op-55, Op-83, Om-9, Os-86, Osls-79, Op-27, Og-80, Oma-29, O-208, Oma-11, Osb-8, Ostl-3 and Ot-5.

Appendix Table A-23. Continued.

River and Sample Site	Similar benthos communities ($C \geq 50$) listed in descending order of similarity
On-33	
OBS-0	
Oln-132	Oma-23, Ogv-17, Otv-30, Ogv-12, Op-27, Oad-1, On-105, Op-55, Op-83, Od-6, Ostl-3, Omw-6, Obb-5, Omal-3 and Os-82.
Oln-17	Otv-30.

Appendix Table A-24. Benthic macroinvertebrate cluster groups in the Osage River Basin.

Cluster Set Description	Sample Sites Within Each Cluster
I. Family Chironomidae (midge) - Tricorythodes sp. (mayfly) - Cheumatopsyche spp. (caddisfly)	Oma-11 (0); Oaw-10 (0); Osb-8 (I); Ot-5 (0); O-33 (0); Obb-5 (0); Omdc-9 (P); O-183 (0); O-271 (P); O-238 (P); Ost-6 (I); Oma-29 (0); O-208 (0); Os-35 (I); Oad-1 (0); Ogv-12 (0); Ogv-17 (0); Op-27 (0).
II. Stenonema spp. (mayfly) - Family Chironomidae - Optioservus sp. (beetle)	On-85 (0); Op-55 (0); Op-83 (0); Osls-79 (I); Oscl-1 (I); Od-6 (0); Os-82 (I); Os-86 (I); Ostl-3 (I).
III. Class Oligochaeta (segmented worm)/ Family Sphaeriidae (fingernail clam) - Family Chironomidae	Omg-7 (P); Osbh-3 (I).
IV. Stenelmis spp. (beetle) - Family Chironomidae	Opl-46 (0); Opl-63 (0); Ow-11 (0).
V. Cheumatopsyche spp. - Family Chironomidae - Stenelmis spp.	Og-49 (P); Olo-5 (P); Og-80 (P); Om-9 (P); Omw-6 (P); Ogd-7 (P); Ogtm-3 (P); Om-24 (P); Osb-21 (I); Osch-14 (I).
VI. (Medium/High Density) Family Chironomidae - Class Oligochaeta/Family Sphaeriidae - Stenacron interpunctatum (mayfly)	Oma-46 (0); Ogte-5 (P); Occ-11 (0); Oss-11 (P); Og-100 (P); Os-4 (I); Oge-7 (P); Ogtw-3 (P); Ogb-5 (P); Oc-10 (P); Osls-103 (I).
VII. Family Simuliidae (blackfly) - Cheumatopsyche spp.	Oaw-5 (0); Oawm-1 (0); Omdc-24 (P); Ogds-1 (P); Omdcm-12 (P); Omdcml-1 (P); Ogdb-5 (P); Osls-98 (I).
VIII. Cheumatopsyche spp. - Family Chironomidae - Order Ephemeroptera (mayfly)	Og-17 (0); Omdcm-4 (P).
IX. Family Chironomidae - Order Ephemeroptera - Order Plecoptera (stonefly)	Oma-23 (0); Oln-132 (0); Otv-30 (0); On-105 (0); Oln-17 (0).

Appendix Table A-24 (continued).

Cluster Set Description	Sample Sites Within Each Cluster
X. Order Ephemeroptera - Order Plecoptera - Family Chironomidae	Omal-3 (O); Otv-6 (O).
XI. *Cheumatopsyche* spp. - *Stenonema* spp. - Family Chironomidae	Op-13 (O); Olo-4 (P); Osc-1 (I).
XII. (Low Density) Family Chironomidae - Class Oligochaeta/Family Sphaeriidae - *Stenacron interpunctatum*	Ogt-18 (P); O-4 (O); Ogts-2 (P); Os-49 (I); Omlw-9 (P).
Sites not grouped in above cluster sets.	Oss-18 (P) Osch-131 (P) Osc-20 (I) On-33 (O) OBS-O (Spring) O-78 (O) O-67 (O)

P - Prairie stream site
I - Intergrade stream site
O - Ozark stream site